

Executive Summary

In 2002, the South Carolina Department of Health and Environmental Control (DHEC) Environmental Surveillance and Oversight Program (ESOP) monitored all environmental media for impacts from the Savannah River Site (SRS) and compared data with the SRS monitoring program. Samples from groundwater, surface water, air, milk, soils, sediments, drinking water, game animals, fish and vegetation were collected and evaluated for both radiological and non-radiological contaminants. Monitoring results indicate that the SRS continues to impact the environment in several media, but the majority of the contamination remains on site. The levels of contaminants off site remain low and in some cases are decreasing. The primary media impacted are fish, game, air, surface water and groundwater. These media show higher levels of contamination on or adjacent to the site than levels detected in background monitoring sites. With the exception of some fish and soils data, comparisons between the ESOP and SRS monitoring programs were favorable and within the same order of magnitude. Most of the disparity in results could be attributed to natural variation in the media being compared or differences in sample locations.

Tritium continues to be the major contaminant being released to the environment. The main sources for tritium releases to surface water and groundwater are the Effluent Treatment Facility (ETF), and groundwater plumes originating from reactor areas and the Old Radiological Waste Burial Ground. Primary air releases are from the canyons, fugitive source and releases from the tritium replacement facility.

Monitoring and data comparisons will continue to be the primary vehicles for evaluating environmental impacts from the SRS. In addition to monitoring, the ESOP will be evaluating the SRS monitoring programs for effectiveness in detecting, identifying and quantifying contaminants being released by the site. As new missions and facilities are added the need for an active environmental surveillance program will continue. As facilities are removed or placed under institutional controls through the site clean up program, the need for verifying the effectiveness of these controls will also be a prime responsibility for an independent monitoring program.

For 2002 the ESOP will continue its monitoring program and begin work on a critical pathway project to identify the primary contaminants and pathways of environmental transport and exposure. The ESOP will also be participating in a variety of outreach activities, initiating an edible vegetation project, and will seek to increase the number of colocated sample sites to improve opportunities for data comparison. ESOP maintains an independent surveillance program to supplement Department of Energy - Savannah River Site (DOE-SR) monitoring activities, and evaluate the effects of the SRS on public health and the environment. To assist in this mission, the ESOP independently evaluates the SRS non-regulatory environmental monitoring programs through an established multi-media network on and around the Site. The environmental monitoring data generated provides direct information about the concentrations of radionuclides in the air, water, vegetation, and foods near the Site.

ESOP uses the information gathered from these efforts to determine if the DOE-SR activities are protective of the public health and the environment. In addition, this information helps the ESOP

support emergency response activities in the event of an unplanned release of radioactive materials; educate the public on monitoring activities around the SRS; and provide recommendations to the DOE for improving their environmental monitoring programs.

The ESOP environmental surveillance network includes: determining Radiological Atmospheric Quality Adjacent to SRS; monitoring Groundwater Quality adjacent to the SRS; Drinking Water Quality Monitoring; Radiological Surface Water and Sediment Surveillance; Non-Radiological Sediment and Surface Water Quality Monitoring; Radiological Surveillance of Surface Soils On and Adjacent to the SRS; Radiological Monitoring of Terrestrial Vegetation On and Adjacent to SRS; Radiological Monitoring of Dairy Milk; Radiological Monitoring of Fish in the Savannah River; Game Animal Monitoring Adjacent to SRS; Oversight Monitoring and Support Activities.

The implementation of radiological and non-radiological surveillance monitoring by ESOP six years ago has resulted in a significant increase in the understanding of the concentrations and movement of radioactive contaminants in the environment on and around the SRS. The knowledge gained aids in tracking releases from Site facilities, identifying pathways for potential exposure and coordinating with emergency responders for more effective emergency planning. ESOP is also actively involved in field oversight projects to verify the validity and effectiveness of monitoring activities at Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) sites. Additional projects are being considered to provide information for new proposed SRS facilities and to fill data gaps and evaluate other SRS non-regulatory monitoring programs. This improvement in monitoring capability underscores the commitment by the DHEC to fulfill its mission while reinforcing the DOE's commitment to improving open communication and cooperation with host states.

This 2002 ESOP Data Report provides a summary of the ESOP environmental monitoring results generated during the 2002 calendar year. The data and information presented are in accordance with the ESOP's Standard Operating Procedures and project monitoring plans. Copies of environmental reports may be obtained by contacting:

Kimberly Newell, Public Information Director
South Carolina Department of Health & Environmental Control
206 Beaufort St., Aiken, SC 29801
(803) 641-7670 E-mail: newellkr@dhec.sc.gov

Table of Contents

Executive Summary

Introduction	i
--------------------	---

List of Illustrations	iv
-----------------------------	----

List of Appendices	v
--------------------------	---

Glossary	vi
----------------	----

2002 Atmospheric Monitoring

Radiological Atmospheric Quality Adjacent to SRS	7
--	---

2002 Water Monitoring

Ambient Groundwater Quality Adjacent to SRS	10
Drinking Water Quality Monitoring	12
Radiological Surface Water and Sediment Surveillance	15
Non-Radiological Surface Water and Sediment Monitoring	19

2002 Terrestrial Monitoring

Radiological Surveillance of Surface Soils on and Adjacent to SRS	22
Radiological Monitoring of Terrestrial Vegetation on and Adjacent to SRS	24
Radiological Monitoring of Dairy Milk	28

2002 Biological Monitoring

Radiological Fish Monitoring Associated with SRS	30
Radiological Game Animal Monitoring Adjacent to SRS	37

2002 New Initiatives	44
----------------------------	----

Table of Contents

Illustrations

Figures

Figure 1. Average Gross Beta for TSP at the SRS Perimeter	8
Figure 2. Average Ambient Beta/Gamma at the SRS Perimeter	8
Figure 3. Average Atmospheric Tritium at the SRS Perimeter	8
Figure 4. Average Tritium Concentration in the Savannah River	13
Figure 5. Tritium Activity at Four Mile Creek 2000-2002	16
Figure 6. Mean Tritium Data Trends Between ESOP and DOE-SR	17
Figure 7. SRS and ESOP Nitrate Levels in Four Mile Creek	20
Figure 8. Average Yearly pH levels at Upper Three Runs	20
Figure 9. Tritium in Vegetation for DHEC and SRS	25
Figure 10. Cesium-137 in Vegetation for DHEC and SRS	26
Figure 11. Tritium in Edible Bass for DHEC and SRS	31
Figure 12. Tritium in Edible Catfish for DHEC and SRS	31
Figure 13. Cesium-137 in Edible Bass for DHEC and SRS	32
Figure 14. Cesium-137 in Non-Edible Bass for DHEC and SRS	33
Figure 15. Cesium-137 in Edible Catfish for DHEC and SRS	34
Figure 16. Strontium-90 in Non-Edible Catfish for DHEC and SRS	35
Figure 17. Game Animal Average Off-site Dose	38

Maps

Map 1. Radiological Atmospheric Monitoring Locations	9
Map 2. Ambient Groundwater Network	11
Map 3. Drinking Water Monitoring Locations	14
Map 4. Radiological Surface Water & Sediment Sample Locations	18
Map 5. Non-Radiological Surface Water & Sediment Sample Locations	21
Map 6. Radiological Soil Monitoring Locations	23
Map 7. Radiological Vegetation Monitoring Locations	27
Map 8. Radiological Dairy Milk Monitoring Locations	29
Map 9. Radiological Fish Monitoring Locations	36
Map 10. Radiological Game Monitoring Locations	39

Table of Contents

Appendix A:	Radiological Atmospheric Monitoring Data, 2002
Appendix B:	Ambient Groundwater Monitoring Data, 2002
Appendix C:	Drinking Water Monitoring Data, 2002
Appendix D:	Radiological Surface Water and Sediment Monitoring Data, 2002
Appendix E:	Non-Radiological Surface Water and Sediment Monitoring Data, 2002
Appendix F:	Radiological Surface Soil Monitoring Data, 2002
Appendix G:	Terrestrial Vegetation Radiological Monitoring Data, 2002
Appendix H:	Dairy Milk Monitoring Data, 2002
Appendix I:	Radiological Monitoring of Fish in the Savannah River Data, 2002
Appendix J:	Game Animal Monitoring Data, 2002

Glossary

Cs-137	Cesium-137
DHEC	South Carolina Department of Health and Environmental Control
DOE	US Department of Energy
DOE-SR	US Department of Energy at Savannah River Site
ECOD	Early Construction or Demolition
EPA	US Environmental Protection Agency
ESOP	Environmental Surveillance and Oversight Program
ETF	Effluent Treatment Facility
FFA	Federal Facilities Agreement
GIS	Geographic Information System
ICRP-30	International Commission on Radiological Protection
LLD	Lower Limit of Detection
LSD	Edisto-Savannah District
MCL	Maximum Contamination Level
MDA	Minimum Detectable Activity
NPDES	National Pollutant Discharge Elimination System
PRG	Preliminary Remediation Goal
REMD	Radiological Environmental Monitoring Division
SRS	Savannah River Site
TCLP	Toxicity Characteristic Leaching Procedure
TLD	Thermoluminescent Dosimeter
TSP	Total Suspended Particulates

Units of Measurement

g	gram
L	Liter
mrem	millirem
pCi	picocurie

Radiological Atmospheric Quality Adjacent to the Savannah River Site

ESOP routinely measures atmospheric radionuclide concentrations adjacent to SRS to identify trends or elevations of radiological constituents. Radiological atmospheric monitoring sites (Map 1) are located to provide spatial coverage of the project area where public exposure could occur. A critical pathway study conducted in 2002 confirmed that the inhalation exposure route is one of the major mechanisms for exposure to radionuclides released by the SRS.

Air monitoring capabilities in 2002 included air-monitoring stations with capacity for sample collection of glass fiber filters, precipitation, silica gel columns, and thermoluminescent dosimeters (TLDs). The glass fiber filters were used to collect total suspended particulates (TSP). Particulates were screened weekly for gross alpha and gross beta. Precipitation, when present, was sampled and analyzed monthly for tritium. Silica gel distillates of atmospheric moisture were also analyzed monthly for tritium. TLDs were collected and analyzed quarterly for ambient beta/gamma levels. In 2002 there were no substantive changes to either the DOE-SR or ESOP atmospheric monitoring programs.

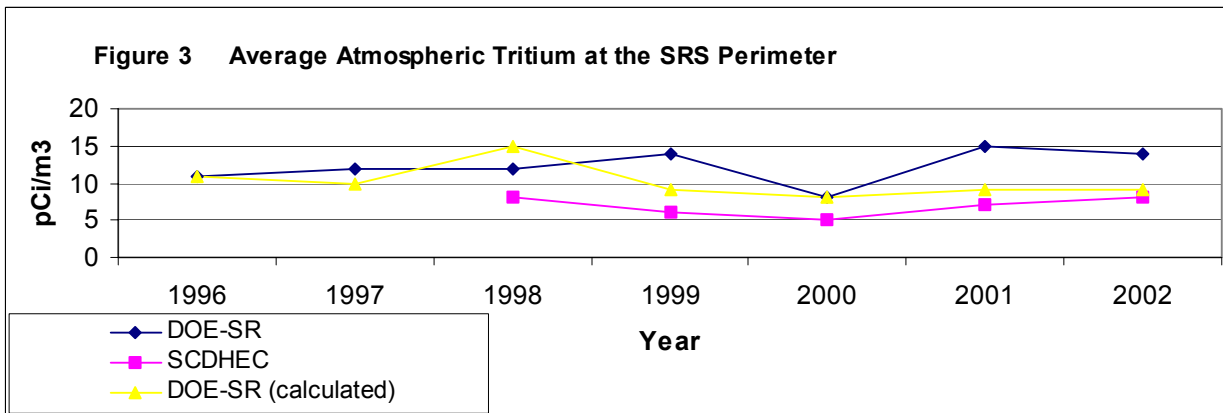
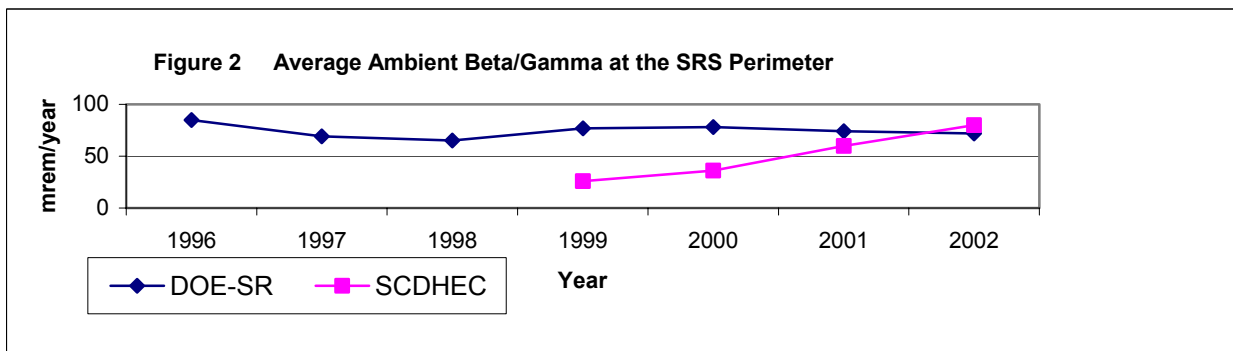
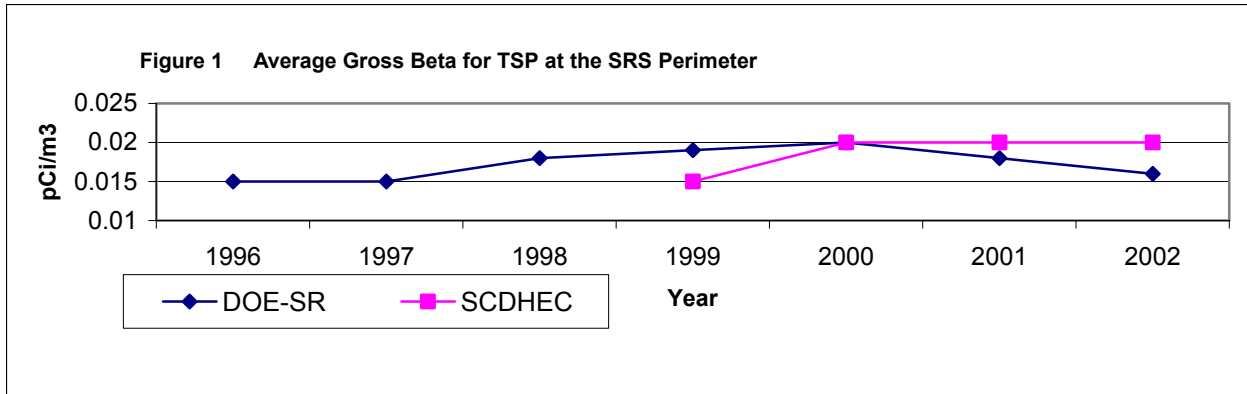
All DHEC data collected substantiated historically reported DOE-SR values for radionuclides in the ambient environment at the SRS boundary.

In general, average DHEC atmospheric radiological monitoring results (**Figures 1-3**) were similar to DOE-SR reported average values and well within the same order-of-magnitude. One possible explanation for the difference in values is that some ESOP “perimeter” monitoring locations are located in adjacent population centers, approximately two miles from the SRS boundary, but included as “perimeter” monitoring locations to increase the number of comparable data points with DOE-SR boundary data.

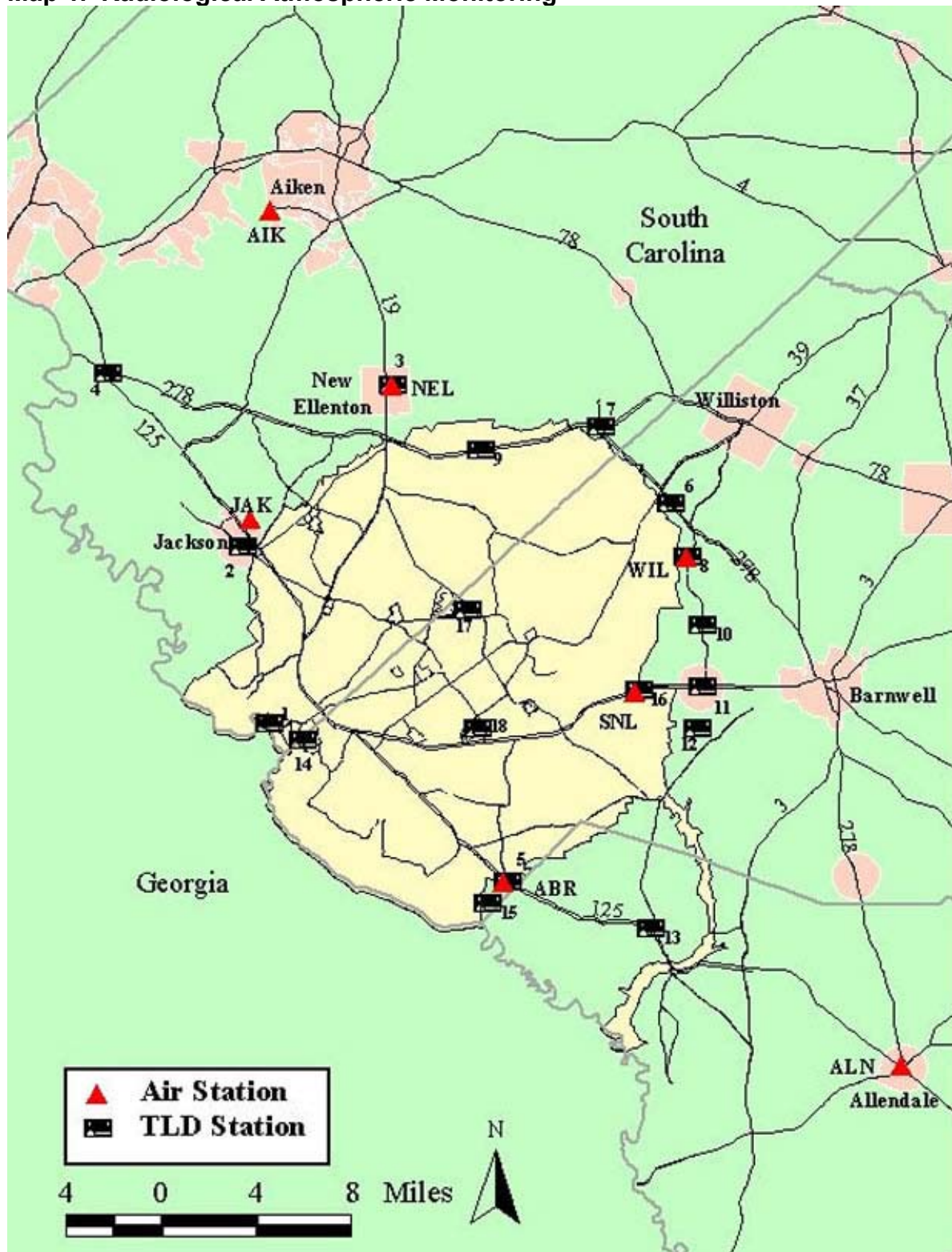
In summary, no Environmental Protection Agency air standards were exceeded at the monitored locations and there were no significant elevations of radiological pollutant concentrations associated with SRS operations. ESOP sampling results (**Appendix A**) by DHEC indicate that SRS activities did have a measurable impact for tritium, but an insignificant impact on local air quality.

Future activities include conducting a TLD comparison with an alternative technology for measuring ambient gamma radiation over time. The new methods called Electrets have some distinct advantages over TLDs; they can be read in the field and redeployed immediately. If results show strong agreement Electrets can potentially be a replacement for TLDs.

This project will continue in 2003 as the atmospheric or inhalation pathway will continue to be a critical pathway for SRS radiological constituents. ESOP will monitor changes in the DOE-SR environmental radiological atmospheric monitoring programs and adjust in-house programs as necessary capture actual or potential SRS atmospheric releases



Map 1. Radiological Atmospheric Monitoring



Ambient Groundwater Quality Adjacent to Savannah River Site

ESOP samples an ambient groundwater quality-monitoring network (“network”) adjacent to SRS. The network is comprised of existing groundwater wells owned by various government agencies, businesses, and members of the public.

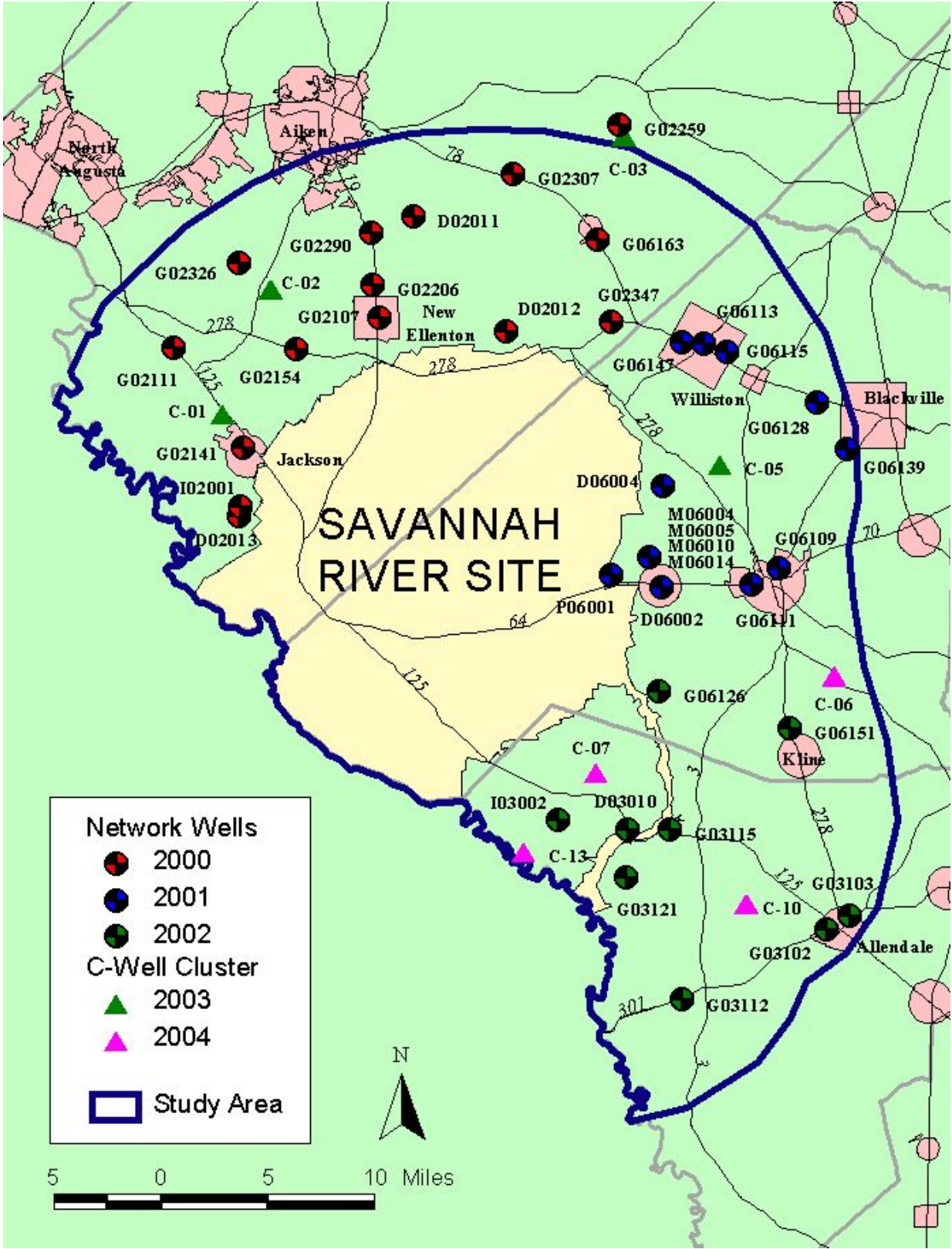
The ESOP Ambient Groundwater Quality Monitoring Project evaluates ambient groundwater quality adjacent to SRS. The study area includes SRS and a 10-mile perimeter from the site boundary in South Carolina. ESOP evaluated five aquifer zones within the study area from the shallow water table to confined aquifers more than 1200 feet deep. The network wells are sampled on a five-year cycle. In 2002, ESOP sampled eight wells from the southeastern portion of the study area (**Map ???**). ESOP analyzed filtered and non-filtered ground water for basic water quality parameters, metals, tritium, gross alpha, non-volatile beta, and gamma-emitting radioisotopes.

Based on a review of the analytical data (**Appendix ???**), no analytes were detected at or above the United States Environmental Protection Agency’s Maximum Contaminant Levels for drinking water.

Due to the complex geologic/hydro-geologic aspect of the study area, direct comparisons could not be made to the groundwater contaminant findings in the latest SRS report (WSRC 2002). However, the network results tend to support SRS’s findings that certain radiological and non-radiological contaminants associated with SRS activities have not migrated off-site to the surrounding communities via the groundwater medium. Therefore, ground water is not considered a viable exposure pathway.

ESOP plans to continue this monitoring project in 2003 by sampling a portion of the well network in addition to some SRS well locations to address network data gaps. It is recommended that naturally occurring radioisotopes continue to be evaluated throughout the study area.

Map 2. Ambient Groundwater Network



Drinking Water Quality Monitoring

The Environmental Surveillance and Oversight Program (ESOP) Drinking Water Monitoring Project evaluates drinking water quality to provide assurance to the public that municipal drinking water systems adjacent to Savannah River Site (SRS) have not been impacted by man-made radiological constituents above regulatory limits. It also provides essential data for assessing human health exposure pathways. The project objectives are to collect monthly raw water composite samples from water treatment plants that use the lower reaches of the Savannah River as source water; and to collect quarterly grab samples from selected municipal and large community drinking water systems within 30 miles of SRS. ESOP analyzed samples for gross alpha, nonvolatile beta, gamma-emitting radionuclides, and tritium.

The Department of Energy-Savannah River (DOE-SR) historically sampled 19 water systems semi-annually for radiological constituents. Routine sampling of the 16 groundwater systems ended in mid-1996 when this sampling element was discontinued from the DOE-SR monitoring program. The remaining three systems, which use surface water sources, are currently being sampled by DOE-SR.

The South Carolina Department of Health and Environmental Control (SCDHEC) currently monitors community/municipal water systems for various contaminants, including radionuclides. SCDHEC requires monitoring for man-made and naturally occurring radionuclides for a minimum of four consecutive quarters during system start-up. Monitoring continues quarterly if the running average exceeds the United States Environmental Protection Agency maximum contaminant level (MCL). Monitoring is reduced to once every four years if activities are below the MCL. ESOP supplements this monitoring with quarterly monitoring of selected systems in the vicinity of SRS and by collecting monthly composites of raw surface water from water treatment plants that use the lower reaches of the Savannah River.

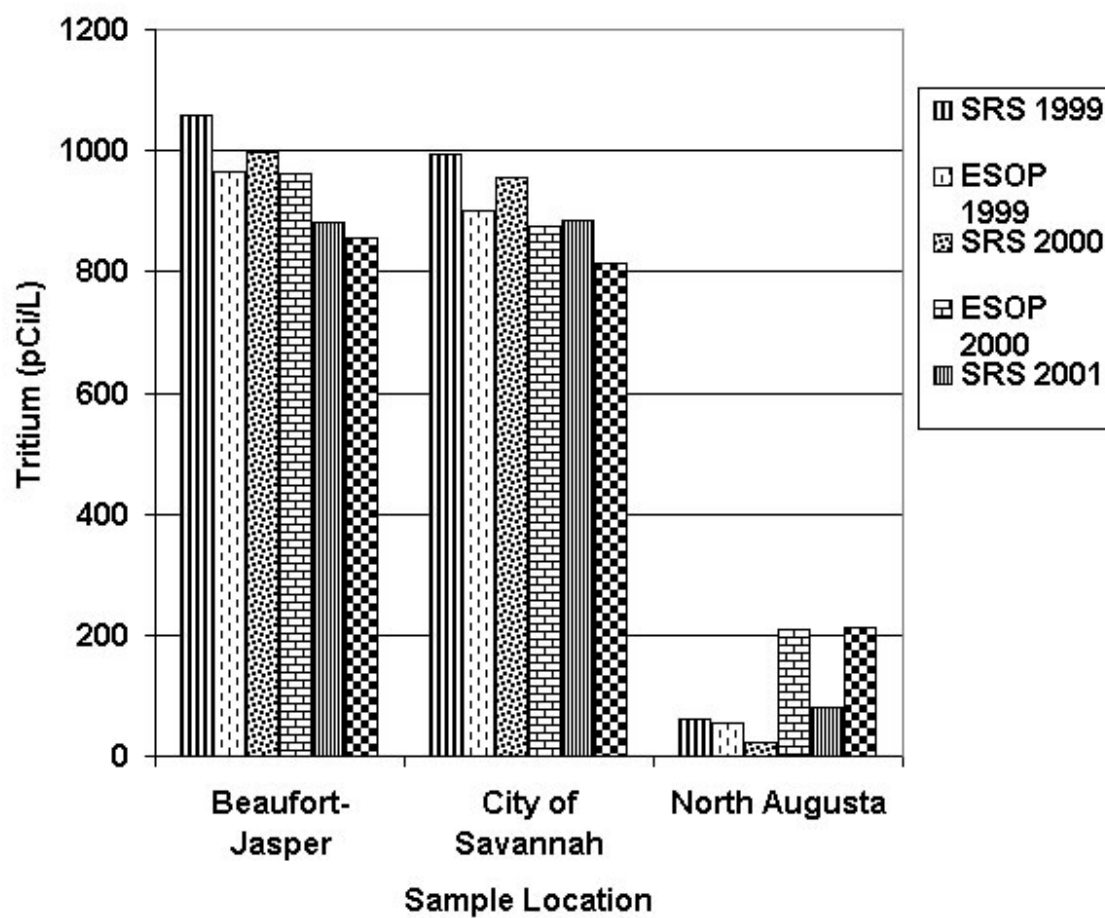
All public water systems in the study area were identified using the SCDHEC Geographical Information System. Nearly all of the municipal and large community systems within the study area were selected for sampling. Of the systems selected, 17 were groundwater fed and three were surface water fed systems. These systems serve approximately 225,000 customers with approximately 96,000 receiving their water from groundwater sources. Monthly and quarterly samples were labeled, preserved, and transferred to a laboratory with a chain-of-custody. Samples were submitted to the Edisto Savannah District Laboratory for tritium analysis. SCDHEC Radiological Environmental Monitoring Division conducted gamma spectroscopy, gross alpha, and gross nonvolatile beta analyses. All data collected was verified, validated, and stored in project files and spreadsheets.

Tritium continues to be the most abundant radionuclide detected in public drinking water supplies potentially impacted by SRS. It was detected in both groundwater and surface water-fed systems. Tritium levels ranged from <175 to 367 pCi/L in groundwater fed system. In raw surface water, the tritium levels ranged from <178 to 1782 pCi/L. These tritium results were well below the 20,000 pCi/L MCL.

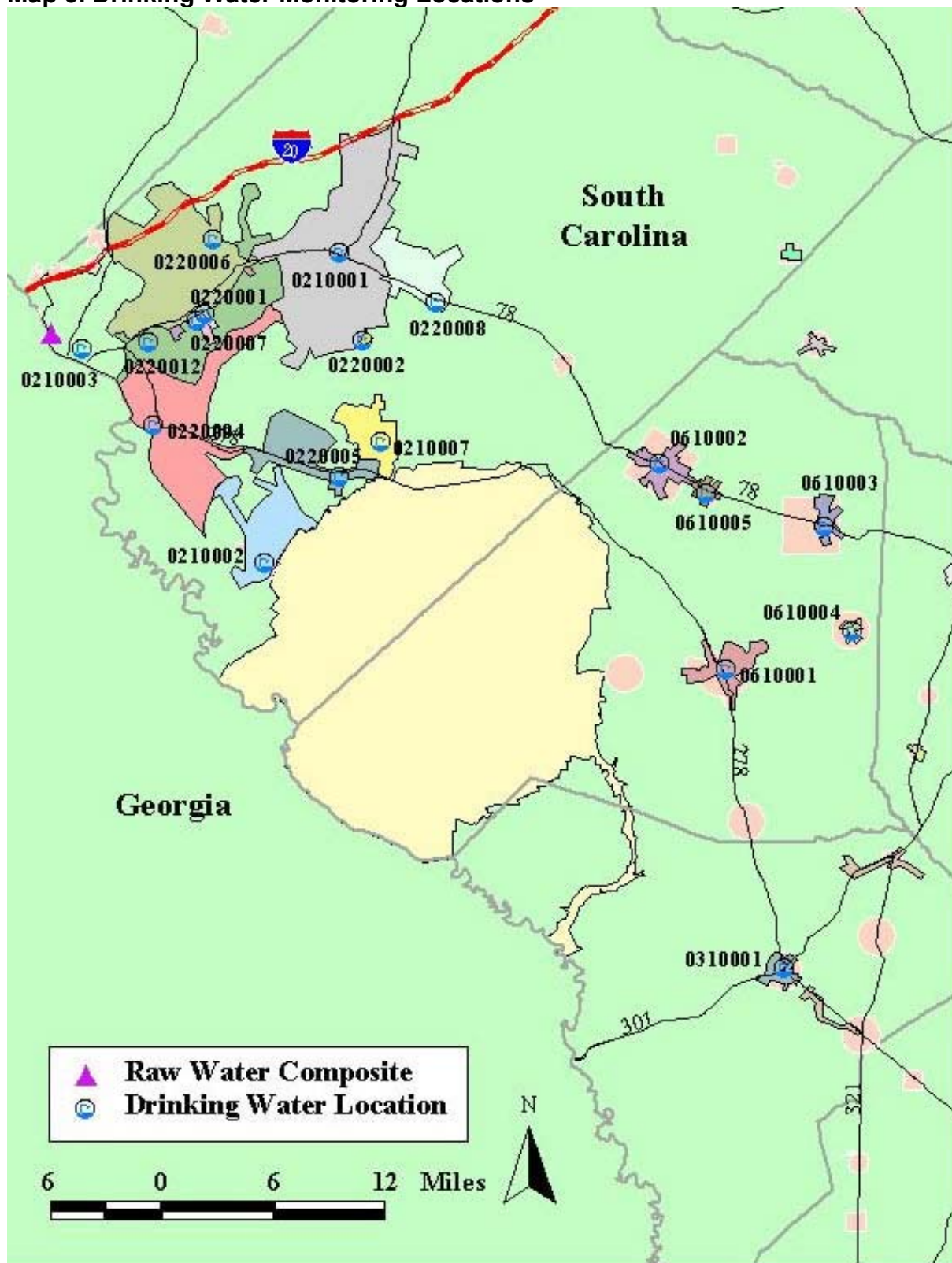
Gamma-emitting radionuclides were not detected at activities above the MDA. Gross Alpha and gross beta radionuclides were both detected in various samples. Gross Alpha ranged from <1.00 to 12.9 pCi/L. Gross beta ranged from <1.52 to 2.92 pCi/L. These detections were below the 15 pCi/L MCL. Beginning in 2003 all gross alpha samples that are greater than or equal to 5 pCi/L will be sent to a contract lab to be analyzed for radium-228 and radium-226. More complete radium analysis has been added due to its detection in public and private wells in the area.

The ESOP Drinking Water Monitoring Project continues to be an important source of essential data for assessing the human health exposure pathways. Continued monitoring is required because of increased disturbance from accelerated clean up and the potential for new emissions. ESOP will continue sampling to provide the public with an independent source of radiological data for drinking water systems adjacent to SRS.

Figure 4. Average Tritium Concentration
in the Savannah River



Map 3. Drinking Water Monitoring Locations



Radiological Surface Water and Sediment Surveillance

The purpose of the Radiological Surface Water and Sediment Project has been to collect and analyze surface water and sediments for radionuclides; compare results with historical SRS data; enhance surface water and sediment databases; characterize trends of radionuclides in streams and sediments associated with SRS; and provide the public with independently generated data.

The radiological surface water and sediment sampling program consists of ambient sample locations and enhanced sample locations. The program had a total of 13 surface water locations, five creek mouth locations, and 17 sediment locations. Surface water was collected three days per week from seven enhanced surface water locations and once a week from the six ambient locations. These samples are analyzed for tritium. In addition, surface water samples were collected into station specific monthly composites and were analyzed for gross alpha, gross beta, and gamma-emitting radionuclides. Stream water was also collected once a month from five Savannah River creek mouths. These river locations were monitored for tritium. Sediment samples were collected in June 2002 and analyzed for gross alpha, gross beta, and gamma-emitting radionuclides.

The enhanced surface water monitoring program provides downstream drinking water customers with advance notice of an SRS release. This early detection component consists of continuous monitoring of six SRS streams that flow to the Savannah River. ISCO[®] automatic samplers collect approximately 30 milliliters of stream water every 30 minutes. ESOP personnel collected these composite samples every Monday, Wednesday, and Friday. Samples were analyzed for tritium on the day of collection by the LSD laboratory. Results from the tritium analysis were used to project tritium activity in the Savannah River. There were no releases above expected activities or that warranted regulatory action during the 2002-2002 sampling period.

There were two project changes during the 2002-2002 fiscal year. The Highway 301 Bridge (SV-118) location was added to the enhanced monitoring routine to increase sample frequency. Second, the Pen Branch (SV-2048) location at S.C. Highway 125 was re-located to a stream station on SRS Road A-13 (SV-2047), enabling ESOP and DOE-SR to have co-located Pen Branch sampling stations.

ESOP detected tritium activity above background levels at all sample locations. Four Mile Creek and Pen Branch continue to present higher levels of tritium activity. The measured tritium activity in each of these streams is greater than the EPA maximum contaminant level of 20,000 pCi/L for drinking water. Tritium activity from all surface water sampling stations ranged from <MDA to 143,960 pCi/L, with Pen Branch (SV-2047) having the highest activity. In addition, ESOP analysis of samples collected at the Four Mile Creek mouth (SV-2015) indicate that the public could be exposed to tritium activities greater than 20,000 pCi/L for drinking water at that location.

ESOP analysis of gross alpha activity ranged from <MDA to 2.54 pCi/L. Steel Creek (SV-327) had the highest level of gross alpha activity. Gross beta activity ranged from <MDA to 6.44, with Four Mile Creek (SV-2039) having the highest measured gross beta activity. Cs-137 activity was detected in sediment samples collected in June 2002. The activities ranged from <MDA to 12.24 pCi/g, with Four Mile Creek having the highest measured activity. There were

no detections of Cs-137 activity in any of the surface water samples during the fiscal year 2002-2002.

ESOP will continue collection and analysis of surface water and sediment on and adjacent to the SRS. ESOP monitoring will provide an improved understanding of radionuclide activities in the SRS surface waters and sediment and impart valuable information to human health exposure pathways.

Figure 5. Tritium Activity at Four Mile Creek 2000-2001

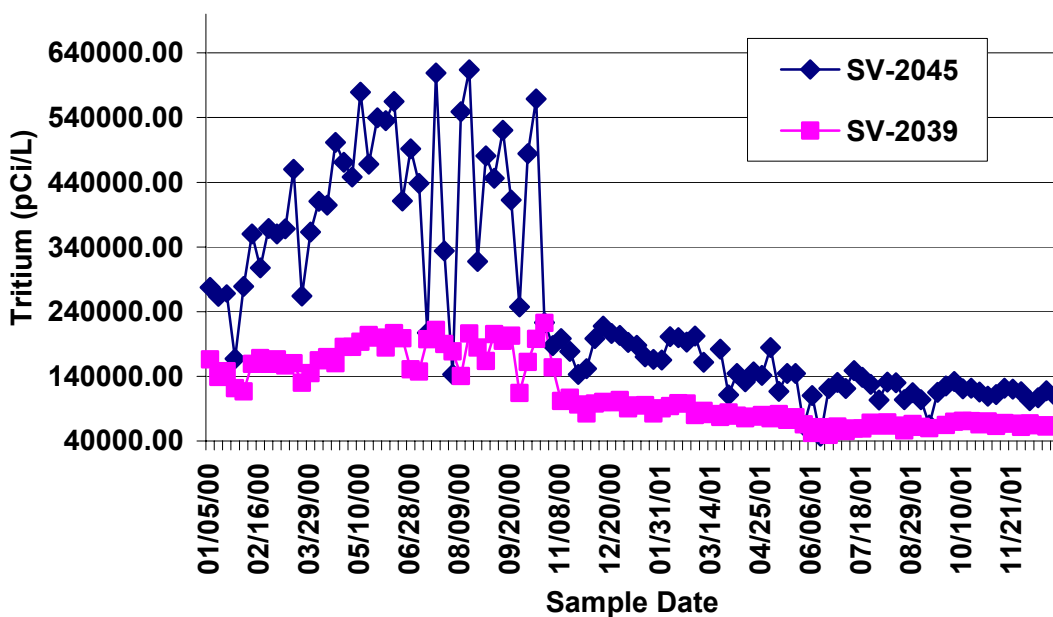
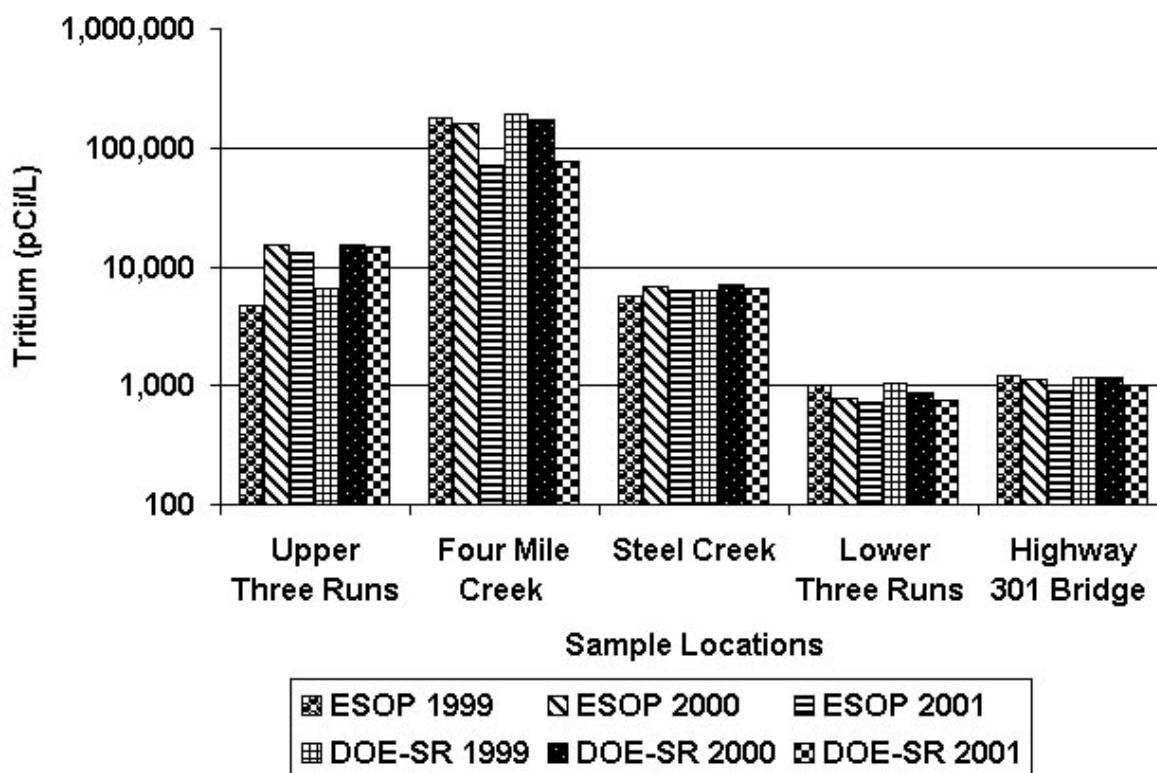
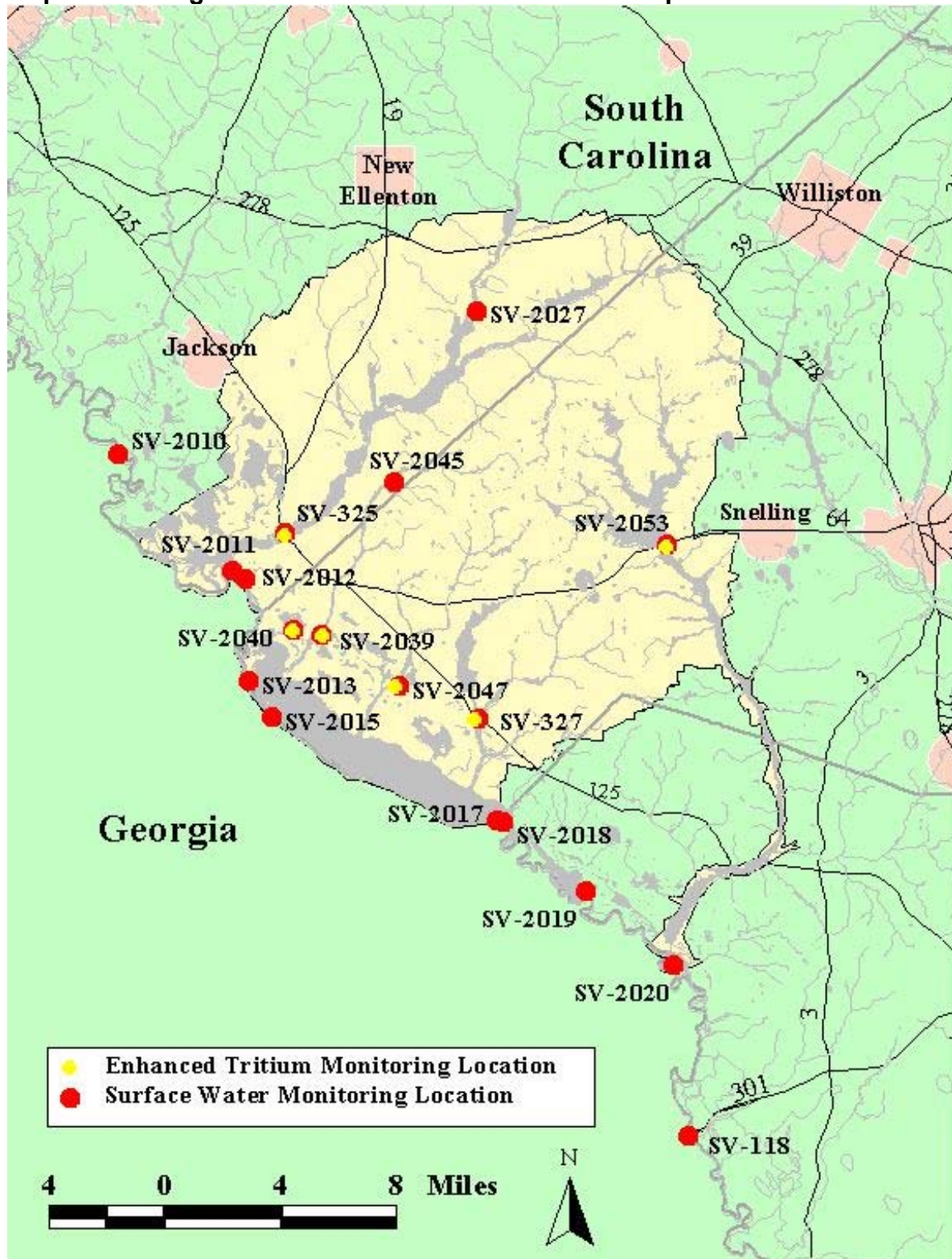


Figure 6. Mean Tritium Data Trends
Between ESOP and DOE-SR



Map 4. Radiological Surface Water and Sediment Sample Locations



Non-Radiological Surface Water and Sediment Monitoring

The streams located on the Savannah River Site (SRS) receive treated wastewater and nonpoint source runoff from on-site facilities. Recent and historical data from SRS Environmental Reports indicate that the SRS waters are in accordance with Freshwaters Standard guidelines stated in the South Carolina Department of Health and Environmental Control (SCDHEC) Water Classifications and Standards (Regulation 61-68), 1998.

The Environmental Surveillance Oversight Program (ESOP) assessed the nonradiological sediment and surface water quality on SRS by sampling the on-site streams for inorganic and organic contaminants. Specific parameters were analyzed monthly, quarterly, and annually. Sample sites were strategically chosen to monitor ambient sediment and surface water conditions to detect nonradiological impact from Department of Energy – Savannah River (DOE-SR) operations. A random sample location was also added for the 2002 sampling year for data enhancement.

Trace amounts of metals were detected in many of the sediment samples. Zinc was the only constituent above the state average at two locations located on Four Mile Creek (SV-326 and SV-2039). Sediment data from this study, as well as 2002 DOE-SR sediment data, indicate no measurable impacts from DOE-SR operations. However, a comparison of SRS and ESOP sediment data could not be completed because of different methods used for analyzing sediments.

The overall nonradiological water quality on the SRS meets the Freshwaters Standard for South Carolina streams. As in previous years, all but two of the surface water parameters, nitrate and pH, continue to be within expected ranges for South Carolina streams. Nitrate concentrations from the Four Mile Creek (SV-326) sample location were higher than comparable South Carolina streams. These elevated nitrate concentrations possibly result from waste treatment facility discharges into Four Mile Creek upstream from this location (WSRC 2002a). A study will be completed in fall of 2003 to determine if the waste treatment facility is the only source of the elevated nitrate concentrations. Also, surface water pH from one of the Upper Three Runs (SV-2027) sample locations continues to be lower than comparable South Carolina streams. This trend is typical for blackwater streams, such as Upper Three Runs. Data from ESOP nonradiological surface water locations were compared to DOE-SR data where sample points were colocated. The data from the colocated stations were similar for the parameters that were analyzed by both ESOP and DOE-SR.

ESOP will continue the nonradiological independent monitoring and surveillance of SRS surface water to verify SRS surface water quality. Continued monitoring is required because of increased land disturbance from accelerated clean-up, logging, and the potential for new emissions. The Nonradiological Ambient Sediment and Surface Water Quality Monitoring Project also provides essential data for assessing the human health exposure pathways. The future locations, numbers of samples, sample frequencies and monitoring parameters may change to maximize available resources and address critical issues.

Figure 7. SRS and ESOP Nitrate Levels
in Four Mile Creek

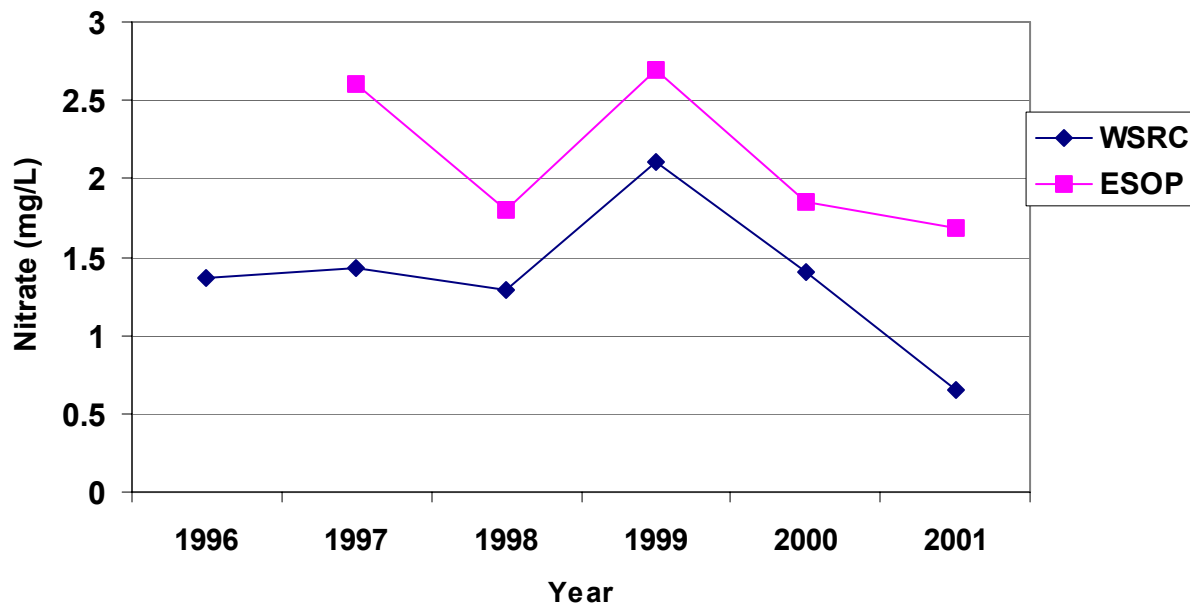
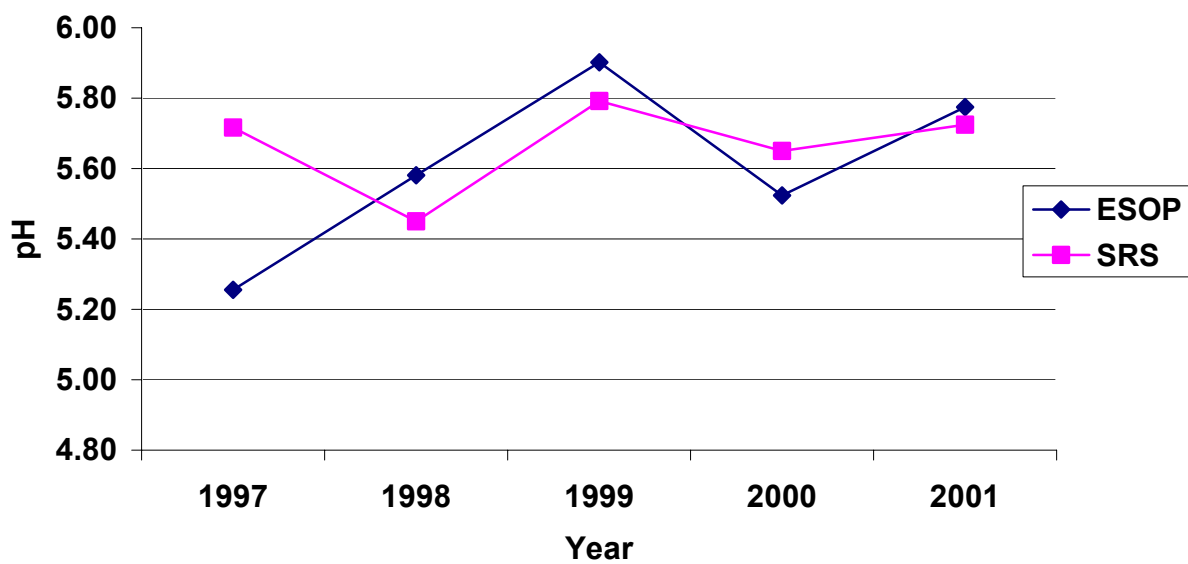
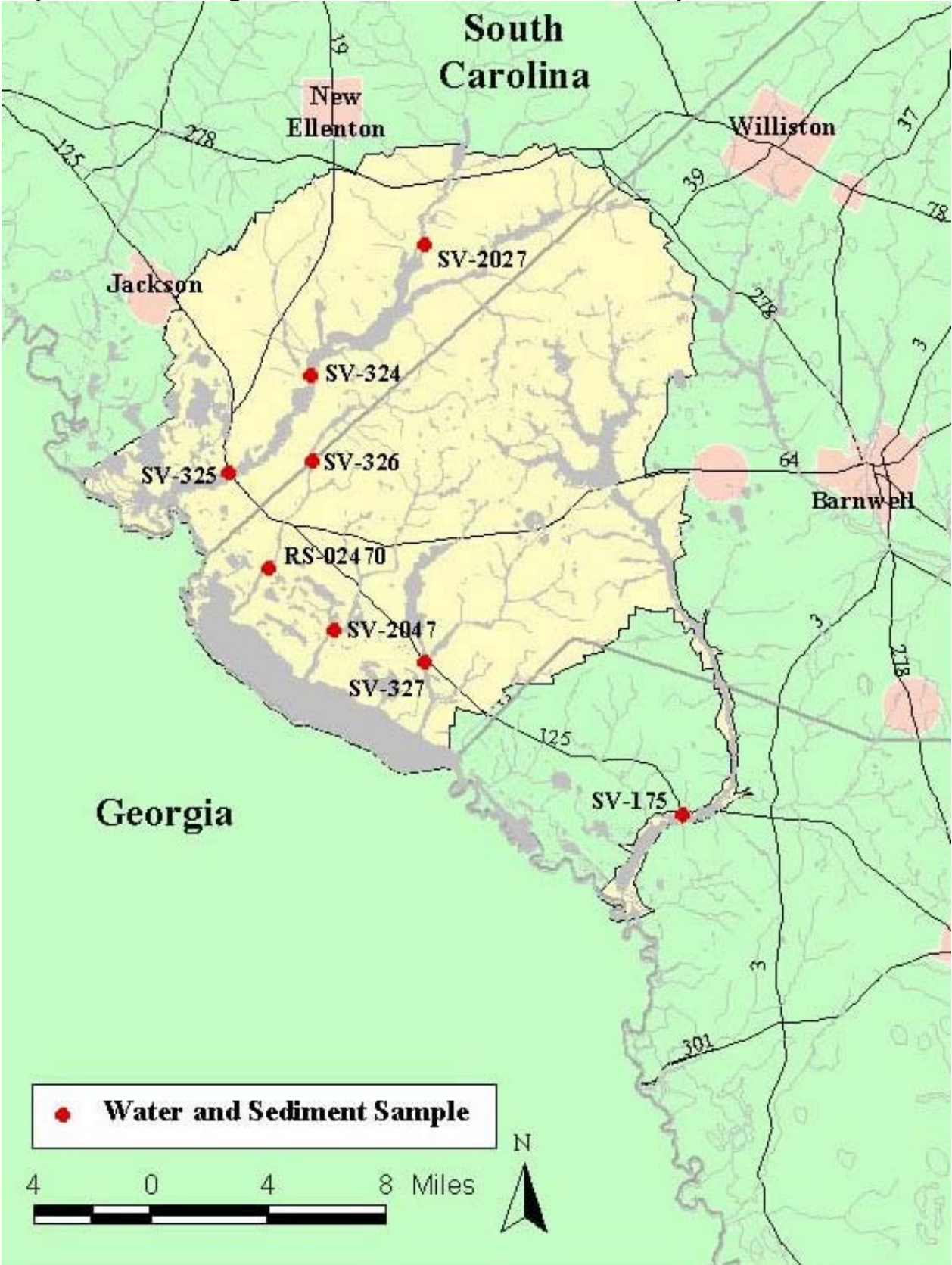


Figure 8. Average Yearly pH levels at Upper Three Runs



Map 5. Non-Radiological Surface Water and Sediment Sample Locations



Terrestrial Monitoring

Radiological Surveillance of Surface Soils on and Adjacent to SRS

The South Carolina Department of Health and Environmental Control (SCDHEC) Environmental Surveillance and Oversight Program (ESOP) provides independent non-regulatory evaluation of Department of Energy – Savannah River (DOE-SR) environmental monitoring programs. ESOP personnel independently evaluated surface soils for possible strontium-89 (Sr-89) and strontium-90 (Sr-90) radionuclide atmospheric deposition concentrations, and a target analyte list of metals on and around the Savannah River Site (SRS) at 17 locations in 2002.

ESOP sampled soil for Sr-89 and Sr-90 for the first time in 2002, and found only one result above zero, 33.4 pico curies per gram (pCi/g) for Sr-89 at the junction of SRS roads A-17 and A-17.2 (BWL-007 location) with a background of zero. The Department of Energy (DOE-SR) Sr-89/90 detect at the junction of Highway 301 and the Savannah River represents a questionable exposure to the public since the detect was less than the minimum detectable concentration. The dose to the public was zero millirems (mrem) for the ESOP SRS perimeter since the BWL-007 location is internal to SRS, and not normally accessible by the public. Thus, strontium did not appear to contribute a measurable amount of radioactive contamination to the atmospheric critical pathway around the perimeter of SRS in 2002.

Metals were sampled in 2002 by ESOP and compared to those sampled in 2002 (Table 1) to provide independent monitoring data to the background soil levels reported by SRS. Looney, et. al. (DOE-SR 1990) found that iron levels in SRS soils ranged from 886 ppm to 79,600 ppm in soil sections down to 10 ft. with a median of < 2 ppm. The available comparative data for the state from a study by Canova indicated that the soil element concentrations detected by ESOP around the SRS perimeter and vicinity are typical of the South Carolina Coastal Plain (Chart 1) physiographic province except for iron. The highest iron level in 2002 occurred at the BWL-007 location (29,000 ppm), and is more typical of the Piedmont region of South Carolina.

Arsenic levels, while typical of South Carolina Coastal Plain soils (Chart 2), were less than the noncancer (22 ppm) end point, but were typically above the cancer (0.39 ppm) end point for soils (where cancer risk is possible). However, a review of the literature reveals that arsenic readily binds to soil, and only non-detectable levels of arsenic (less than five parts per billion) were indicated for the SRS perimeter groundwater by ESOP in 2002. In conclusion, the soil arsenic levels detected by ESOP in 2002 external to the perimeter of SRS appear typical of the coastal plain of South Carolina, and below environmental quality trigger levels.

The ESOP dose calculation report for the atmospheric and liquid pathways combined contributed less than 1.0 millirems to the overall dose of the MEI for each of the past four years. The overall dose from all pathways was 7.4 mrems in 2002 for the MEI. This is comparable to the dose received by an individual living in a brick or block house.

The ESOP surface soils monitoring project may be expanded in the future, if budgeting permits, to include more randomized coverage; reduced lab minimum detectable concentrations; an

increase in the number of low energy radionuclides monitored; soil profiling; and statistical analysis on splits with SRS.

Table 1. Comparison of Soil Element Average Concentrations by Region of South Carolina

Element	SRS Perimeter Region			SCDHEC Background Soil Concentrations (Canova)			EPA 10/01/02
ppm	2001	2002	Avg 01&02	Coastal Plain	Piedmont	Statewide	PRG '02
Al	4892	6564	5728	5405	24255	13528	76000 nc
Sb	<5	<5	<5				31 nc
As	<10	1.2	1.2	2	11	6.1	22 nc(0.39 ca)
Ba	20	20	20	19	59	38	5400 nc
Be	0.5	0.4	*0.4			0.6	150 nc
Cd	<1	<1	<1			1	37 nc(1.7 ca)
Ca	122	2186	1154			699	
Cr	7	7	*6	7	29	16	210 ca
Co	6	3	*4			4	900 ca
Cu	5	3	*3	5	13	9	3100 nc
Fe	4404	5359	4882	5271	28467	15608	23000 nc
Pb	16	13	*14			16	400 nc(150)
Mg	134	1188	661	260	1916	988	
Mn	90	76	83	22	235	120	1800 nc
Ni	4	3	*3	4	9	6	1600 nc
K	236	159	197	227	1588	856	
Se		<10	<10			0.9	390 nc
Ag	<3	<3	<3			4	390 nc
Na	41	13	27			194	
Tl	<50	<50	<50	11	67	4.5	5.2 nc
V	14	12	*12				550 nc
Zn	5	11	*8	14	34	23	23000 nc
Hg		<0.25	<0.25			0.18	0.00

Notes: All data averages were rounded off to comparable ppm significant figures.

SCDHEC = South Carolina Department of Health and Environmental Control

EPA = Environmental Protection Agency PRG = Preliminary Remedial Goals

Some of the SCDHEC (Canova study) means are from log normal distributions.

The "<" refers to a high lab MDC affecting the average on the high side.

The "*" indicates many "less than" values affecting the average on the low side.

ca = cancer PRG nc = noncancer PRG

The arsenic '01 and '02 average reflects only the '02 data from General Engineering Lab since these detects were well below the 2001 reported MDC of < 10 ppm.

Chart 1. Comparison of Soil Element Average Concentrations By Region of South Carolina

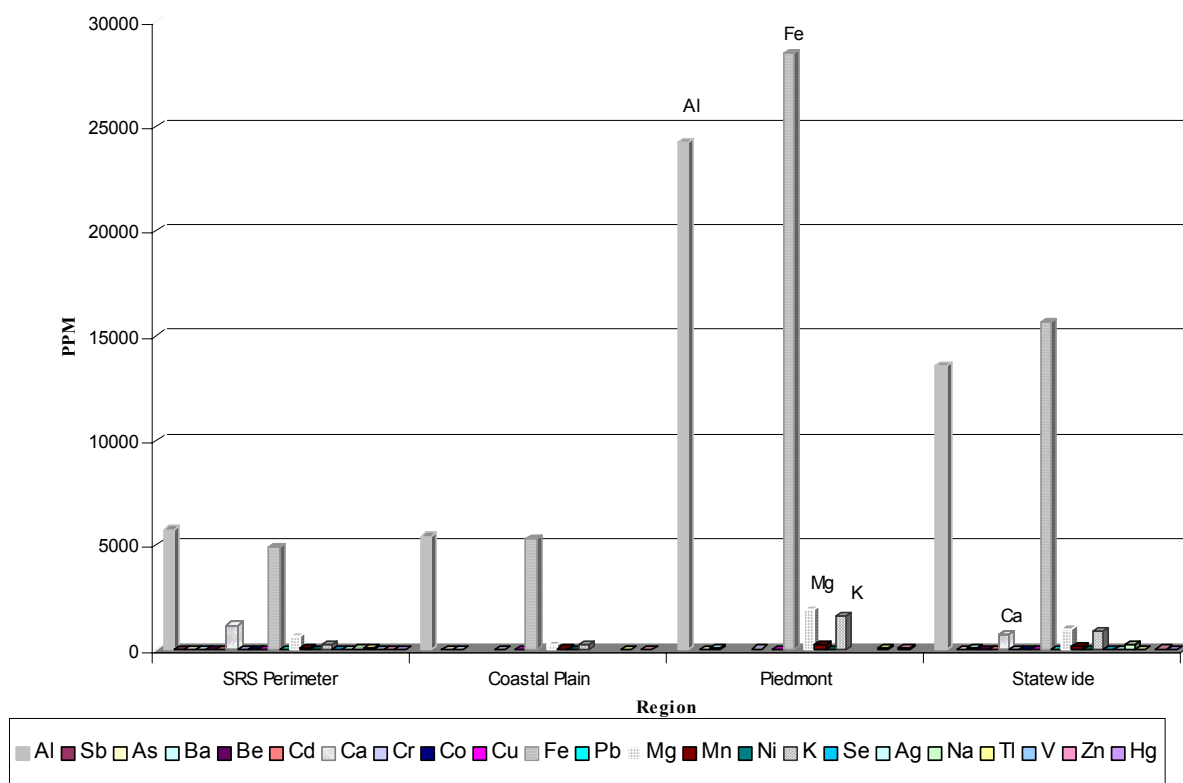
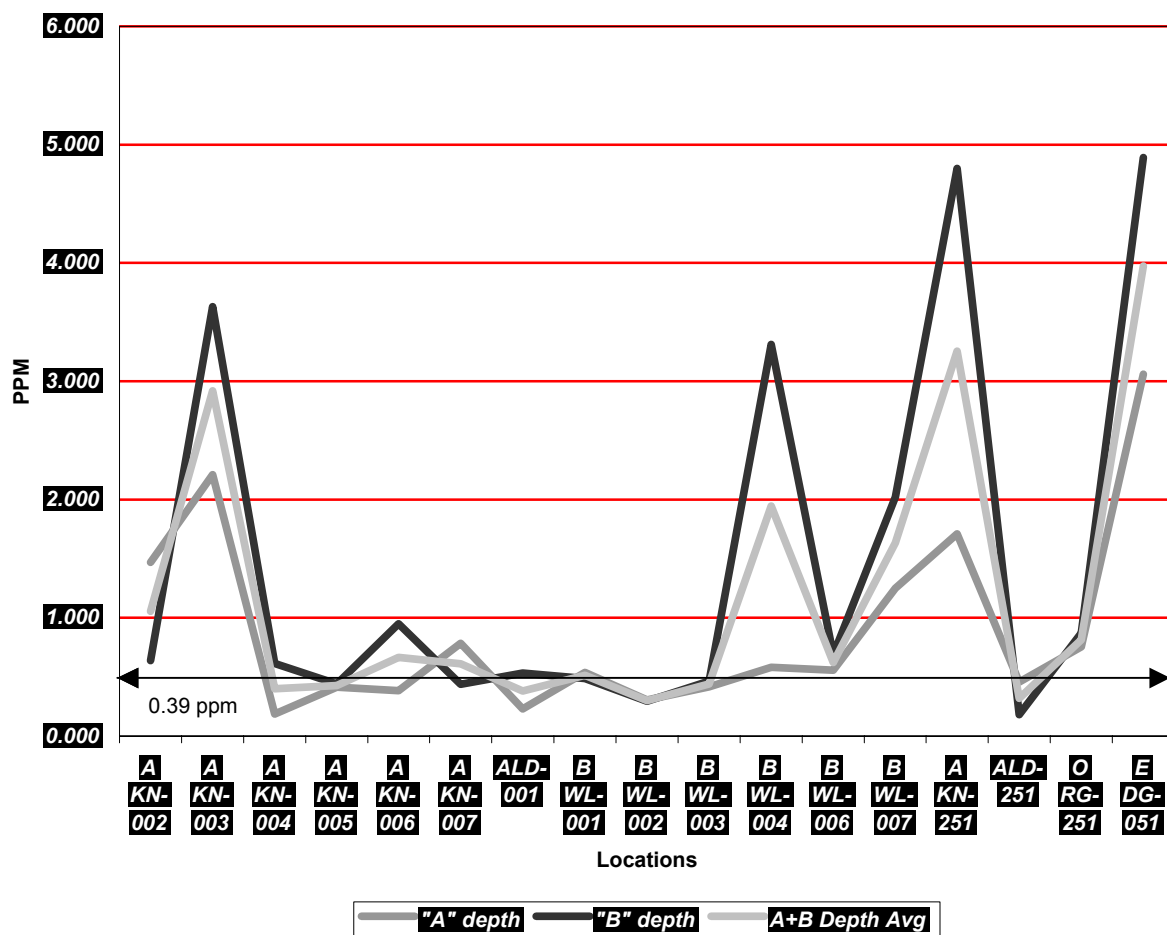
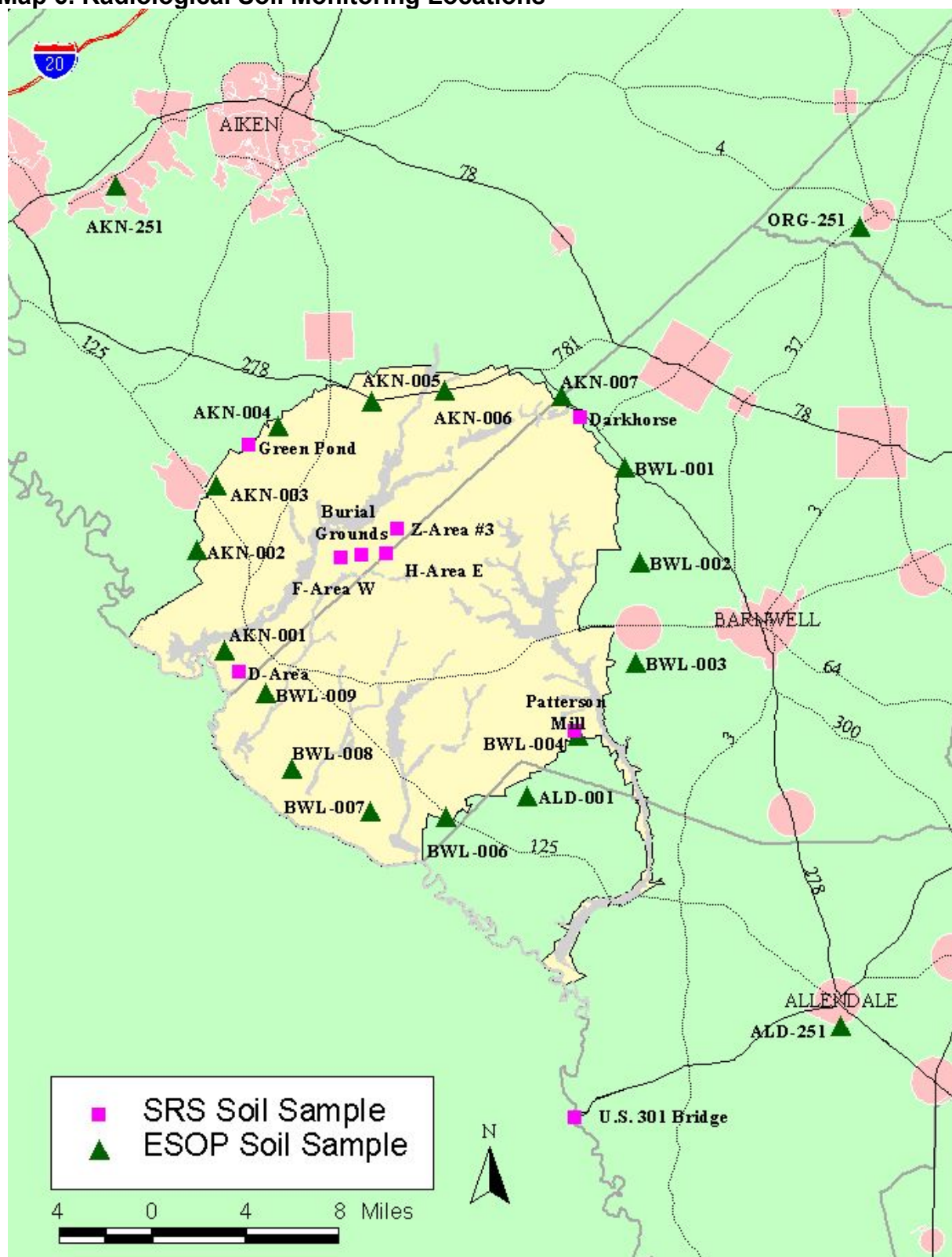


Chart 2. Comparison of Arsenic at SRS Perimeter Locations



Map 6. Radiological Soil Monitoring Locations



Radiological Monitoring of Terrestrial Vegetation On and Adjacent to SRS

The Environmental Surveillance and Oversight Program (ESOP) monitors for the presence of radionuclides in vegetation around the Savannah River Site (SRS) stemming from SRS operations. In 2002, ESOP conducted independent vegetation monitoring at 16 locations around the perimeter of the SRS; three former SRS monitoring locations 25 miles from the center of SRS; and four locations selected at random from within a 50-mile radius of SRS. Sampling was performed in May and August 2002.

Samples from all stations were analyzed for tritium activity. Tritium was detected in vegetation at 15 of the 23 sites sampled in 2002. Ten of the perimeter stations produced tritium levels greater than the Lower Limit of Detection in both sampling months. The stations with the highest detectable activity were generally located on the western and northern sides of the SRS, including vegetation collected near D-Area. This is possibly due to heavy water reprocessing and historical operations at that facility. Tritium was not detected at any 25-mile station but was found at one of the randomly selected stations.

Vegetation was collected for gamma analysis at selected stations where sampling in previous years had consistently produced detectable levels of cesium-137. No 25-mile or randomly selected stations were sampled. Gamma-emitting radionuclides were detected in all samples analyzed. Cesium-137 was detected at similar locations, especially at stations on the northern and southeastern sides of the SRS, as in 1998, 1999, 2000, and 2002.

Samples from five stations were analyzed for strontium (Sr) and plutonium isotopes. Two stations produced laboratory accepted activity levels greater than the Minimum Detectable Activity (MDA) for Sr-89. No activities for Sr-90 met laboratory Reporting Limits. Plutonium-238,239 were not detected above the MDA at any station.

ESOP data confirms the DOE-SR conclusion that elevated tritium levels at the site perimeter are due to atmospheric releases from SRS. Despite monitoring and analysis differences, tritium results from the one location sampled by both ESOP and DOE programs were low or below detection limits. Both programs found the highest level of tritium in the vicinity of D-Area. Results for the co-location were similar for cesium-137. To facilitate comparisons, ESOP recommends that DOE-SR modify its reporting format for tritium, either to picocuries/milliliter, or as picocuries/gram of fresh vegetation (i.e. wet weight).

A review of critical pathways for radiation exposure around SRS indicates that vegetation is an important exposure pathway due to atmospheric releases from SRS sources. Analysis of 2002 samples was used to determine that an increase in monitoring frequency to four quarterly collections in 2003 was warranted. Additional analyses may be conducted to compare soil samples collected in conjunction with vegetation sampling, including soil textural analysis and gamma spectroscopy.

Figure 9. Tritium in Vegetation for DHEC and SRS
(No tritium detected in 1999 and 2000)

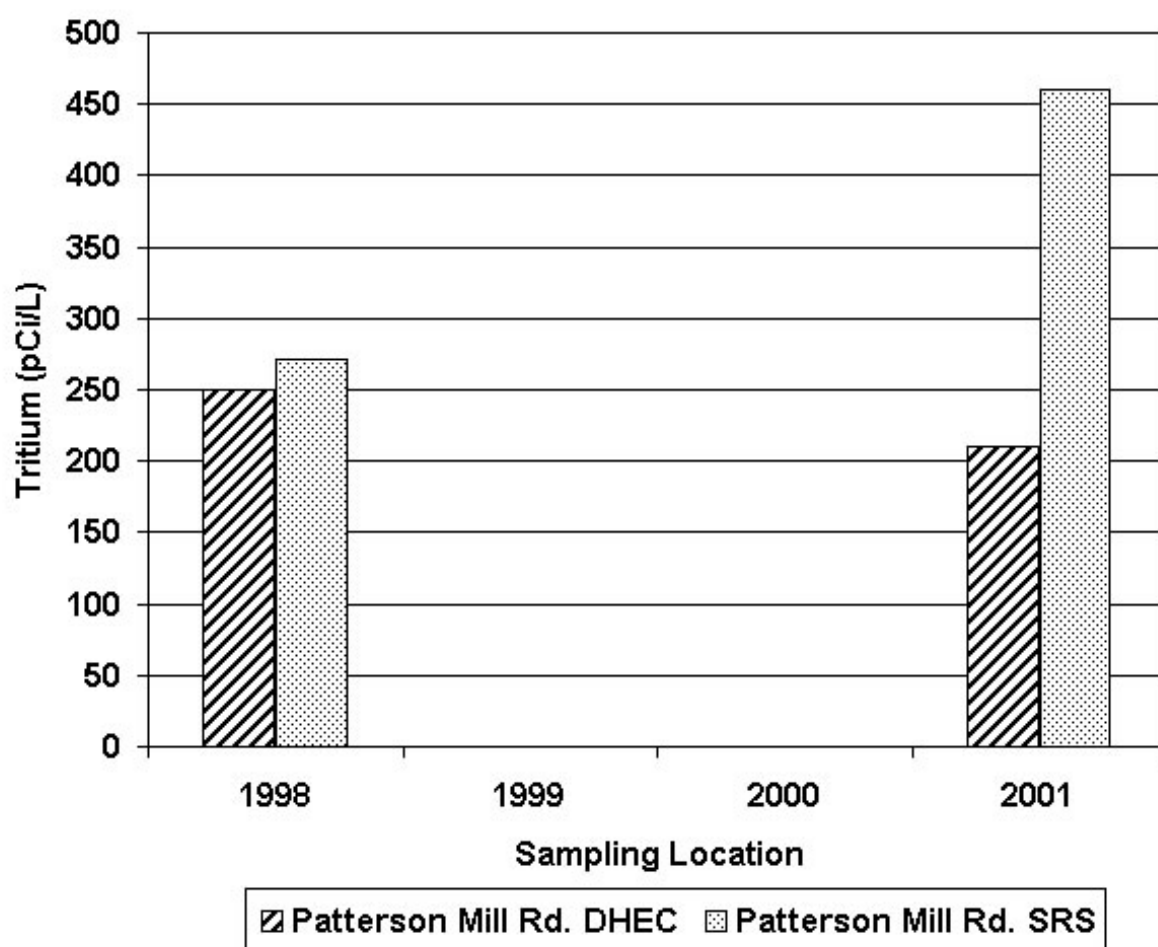
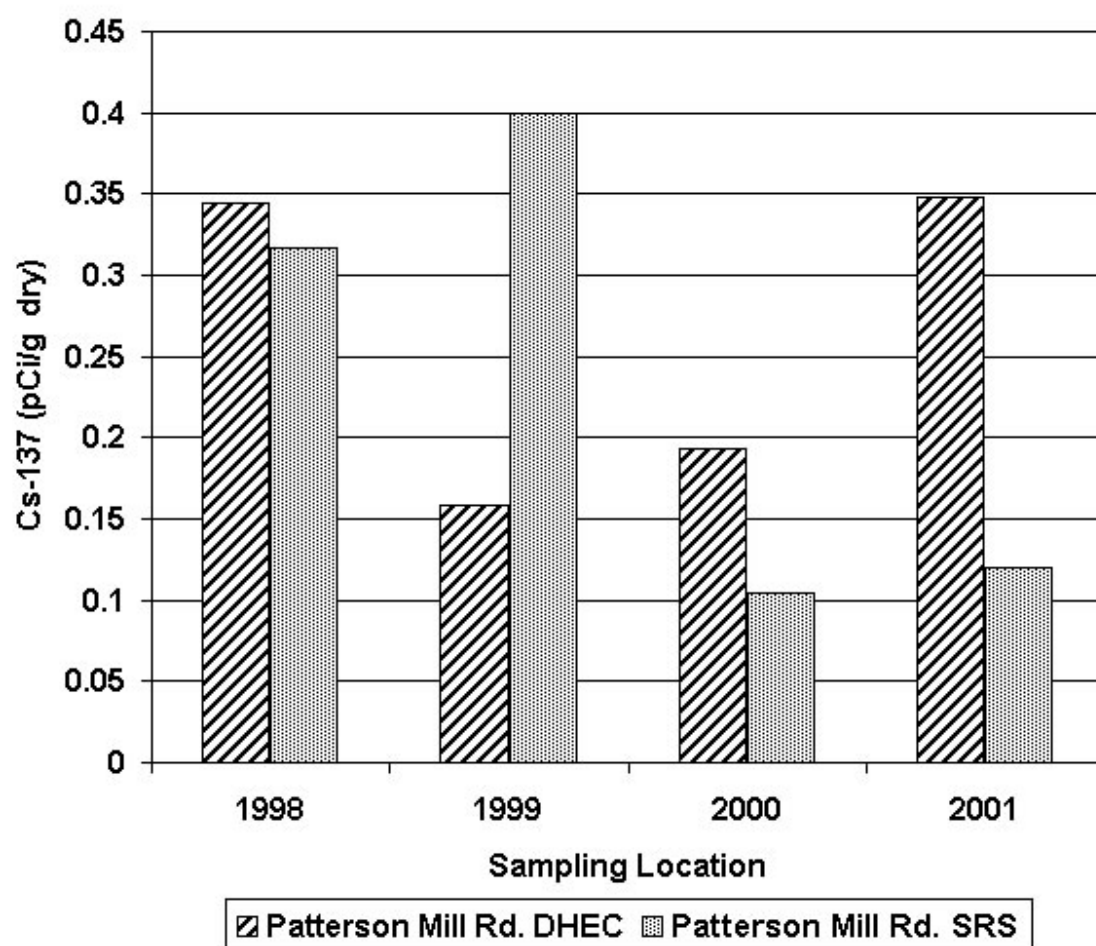
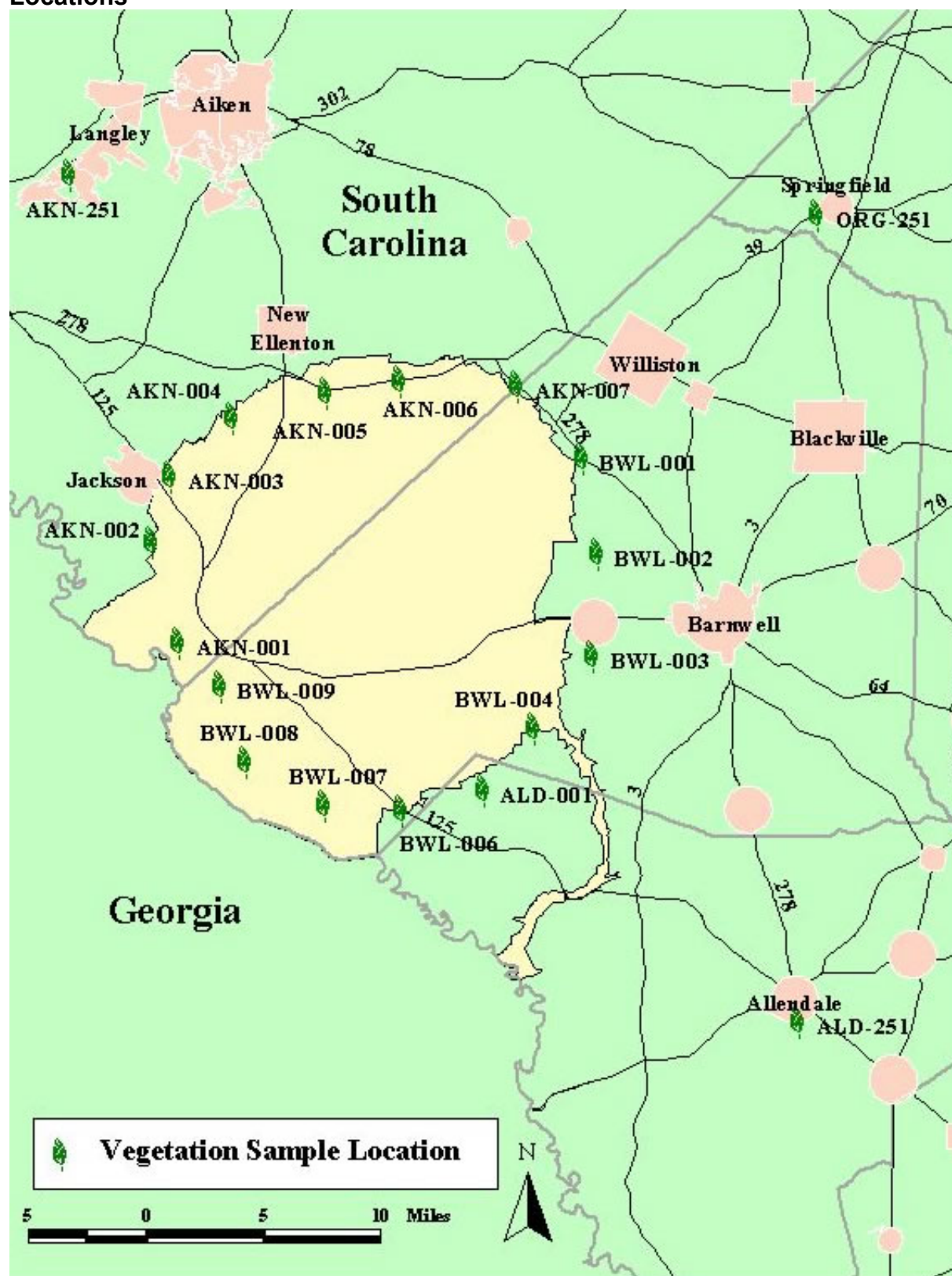


Figure 10. Cesium-137 in Vegetation for DHEC and SRS



Map 7. Radiological Vegetation Monitoring Locations



The Department of Energy – Savannah River (DOE-SR) has historically conducted monitoring on and around the Savannah River Site (SRS) to determine activities of radionuclides in edible vegetation. Edible vegetation can be contaminated externally by direct deposition of airborne materials, water runoff, and precipitation that contains radioactivity. Vegetation can also be contaminated internally by uptake of radionuclides through the root system.

In 2002, the Environmental Surveillance and Oversight Program (ESOP) began a project that conducted independent monitoring at locations within a 10-mile radius of the SRS perimeter. Sampling began in the spring, with a total of 16 samples collected from five communities. The background samples were collected in Lexington, South Carolina. Personnel collected various types of edible vegetation according to the growing season and availability. The samples were analyzed for tritium and gamma-emitting radionuclides.

Tritium levels just above the lower limit of detection (LLD) were detected in seven of the 16 sites. Potassium-40, a naturally occurring radionuclide, was detected in all but one of the samples. Lead-214, another naturally occurring radionuclide, was detected just above the minimum detectable activity (MDA) in two of the samples. Quality Assurance and Quality Control procedures were followed in accordance with established standard operating procedures.

An evaluation of the analytical results indicates a favorable comparison between the SCDHEC ESOP and DOE-SR data for 2002, taking into consideration that DOE-SR utilizes values below the minimum detection levels when reporting their data.

Radiological Monitoring of Dairy Milk

Consumption of milk and other dairy food products containing radioactive materials can be an important source of human exposure to radioactivity via the atmospheric critical pathway. Dairy milk can become contaminated through atmospheric deposition of radioactive particles on vegetation that are ingested by cows and transferred to milk. The atmospheric deposition pathway via milk is of particular importance in the case of infants and children. Not only are they more likely to drink large quantities of milk, they are actively developing bones and teeth. Radioactive strontium, a calcium analogue, can bio-concentrate in bones and teeth displacing the calcium. Since dairy milk is an important pathway for human exposure to radioactivity, milk samples from dairies around Savannah River Site (SRS) are analyzed monthly for levels of radioactivity that could impact human health.

The Department of Energy-Savannah River (DOE-SR) personnel have historically conducted monitoring around SRS to determine concentrations of certain radionuclides in dairy milk. DOE-SR only sampled four locations due to a change in the scope of production activities at SRS and closure of some local dairies. South Carolina Department of Health and Environmental Control (SCDHEC) Environmental Surveillance and Oversight Program (ESOP) personnel only performed dairy milk sampling at three locations to provide an independent source of data on concentrations of radionuclides in milk within a 50-mile radius of SRS.

ESOP personnel collected the milk samples on a monthly basis in 2002. Quality Assurance and Quality Control measures were performed in accordance with ESOP established standard operating procedures (SOP) concerning the collection and evaluation of milk. The samples were analyzed for tritium and select beta-gamma emitters. Tritium was detected in five out of the thirty-six samples collected. The highest tritium concentration was found by ESOP in Norway, SC (803 pCi/L), and was similar to the highest detect found by DOE-SR in Gracewood, GA (833 pCi/L).

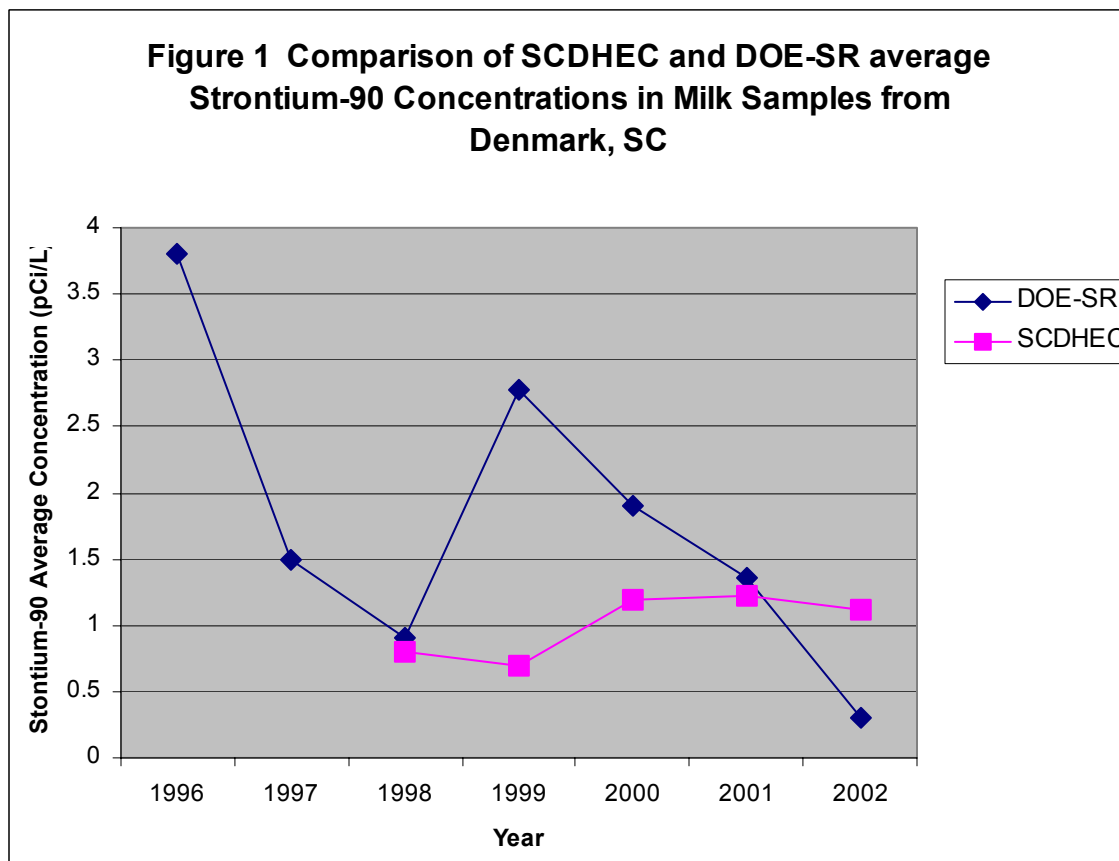
Strontium-90 was not detected in any of the 2002 milk samples. The strontium-90 detect in Figure 1. represents the minimum detection activity limit and not an actual detection. A strontium-89 maximum detect of 3.65 pCi/L occurred at Denmark, SC. DOE-SR did not detect iodine-131 in milk samples, but cesium-137 was detected (3.35 pCi/L) in Girard, GA. This cesium level is probably a result of radioactive fall-out from atmospheric atomic bomb testing conducted by several countries until 1985.

The ESOP dose calculation report for the atmospheric and liquid pathways combined contributed less than 1.0 millirems to the overall dose of the MEI for each of the past four years. The overall dose from all pathways was 7.4 mrems in 2002 for the MEI. This is comparable to the dose received by an individual living in a brick or block house.

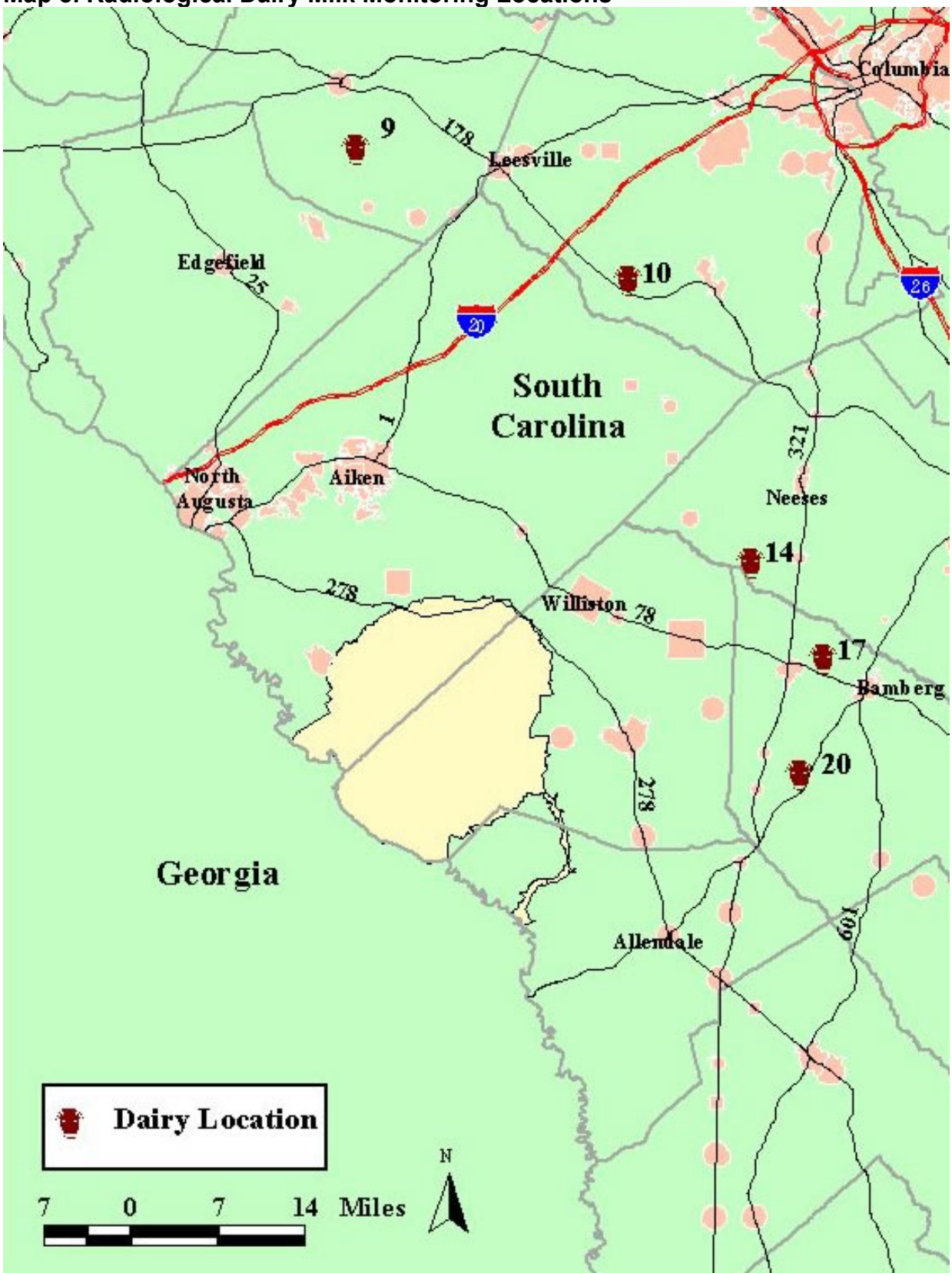
Monthly averages for beta-gamma concentration for each location are consistent with background values. SCDHEC 2002 analytical results were also consistent with DOE-SR. However, the results are limited in scope because the current reporting method used by the DOE-SR utilizes values below minimum detection levels (MDL). This current reporting method is required by the DOE (U.S. DOE 1991).

The off-site potential radiation dose for milk calculated by ESOP to the maximally exposed individual around the perimeter of SRS in 2002 was 0.0 millirems. DOE-SR calculated an off-site dose of 0.0564 millirems in milk for 2002.

ESOP plans to reduce its' cow milk sampling to quarterly collections, but add new cow dairies and goat milk in 2003.



Map 8. Radiological Dairy Milk Monitoring Locations



Radiological Fish Monitoring Associated with the Savannah River Site

The South Carolina Department of Health and Environmental Control (SCDHEC) conducts fish monitoring for radionuclide activity in an effort to determine the magnitude, extent, and trends of radionuclide levels. Five largemouth bass (*Micropterus salmoides*) and five catfish (*Ameiurus catus*, *Ictalurus furcatus*, or *Ictalurus punctatus*) were collected from each of 10 sample locations. Studies have shown that these species bioaccumulate measurable amounts of radionuclides. Bowfin (*Amia calva*) were collected from five locations as part of an ongoing effort to sample additional species each study year.

Fish were collected using boat mounted electrofishing equipment. Samples were collected at five stations where creeks from the Savannah River Site (SRS) meet the Savannah River. In addition, samples were collected at one Savannah River station upstream of the SRS, two stations downstream of the SRS, and two background locations. All fish were composited by species and sample location, and separated into edible and non-edible homogeneous portions. Composites were analyzed for gamma-emitting isotopes and tritium. The non-edible portions of composites from Savannah River stations were also analyzed for strontium.

The Stevens Creek background location was the only sampling area that did not produce detectable tritium activity in any samples. Eight of ten bass samples produced detectable tritium activity. Six of ten catfish samples exhibited tritium activity. Four of five bowfin samples showed tritium activity. A bass composite from the Fourmile Creek location had the highest reported tritium activity, 6801 picocuries/liter.

The two background locations, Stevens Creek and Congaree River, were the only locations where cesium-137 (Cs-137) was not detected in any sample. All bass composites from Savannah River locations produced detectable levels of Cs-137. An edible bass sample from the Lower Three Runs location had the highest reported activity level, 0.72 picocuries/gram. Edible catfish composites from seven Savannah River locations produced detectable levels of Cs-137; non-edible catfish composites produced only one detectable Cs-137 activity, from the Lower Three Runs location. Activities of strontium-90 (Sr-90) greater than the Minimum Detectable Activity were reported from 5 of 16 samples analyzed. Bowfin samples produced three of the five detectable Sr-90 activity levels.

The Department of Energy-Savannah River (DOE-SR) also conducts fish monitoring to assess the effects of current and historical releases of radionuclides. SCDHEC data were compared to DOE-SR reported results. Although there are differences between reported values, the data is consistent with historically reported data. In the past, samples have been collected and split between SCDHEC and DOE-SR for analyses, and no discrepancies in the data results were found. This would potentially rule out methodology differences and substantiate that discrepancies result from the variability in samples analyzed by the two programs.

A review of critical pathways for radiation exposure around SRS indicates that fish consumption is an important exposure pathway due to releases from SRS sources. Independent monitoring of radionuclide levels in Savannah River fish will continue along with evaluating the DOE-SR Radiological Fish Monitoring Program. The information provided will also help in advising,

informing, and protecting the people at risk, and in comparing current and historical data.

Figure 11. Tritium in Edible Bass for DHEC and SRS

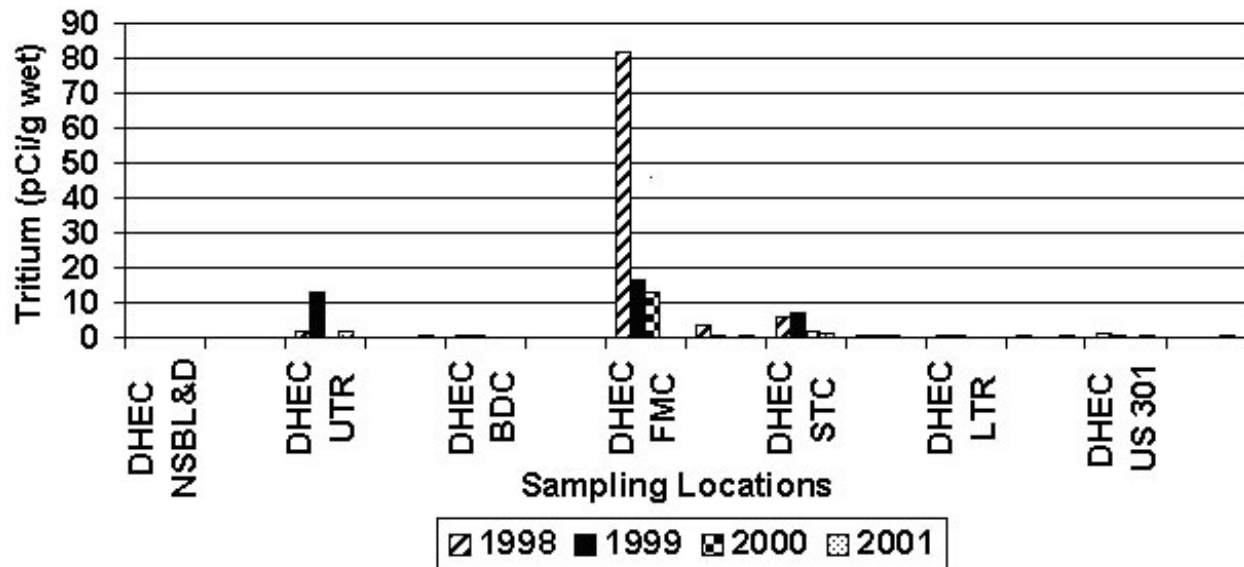


Figure 12. Tritium in Edible Catfish for DHEC and SRS

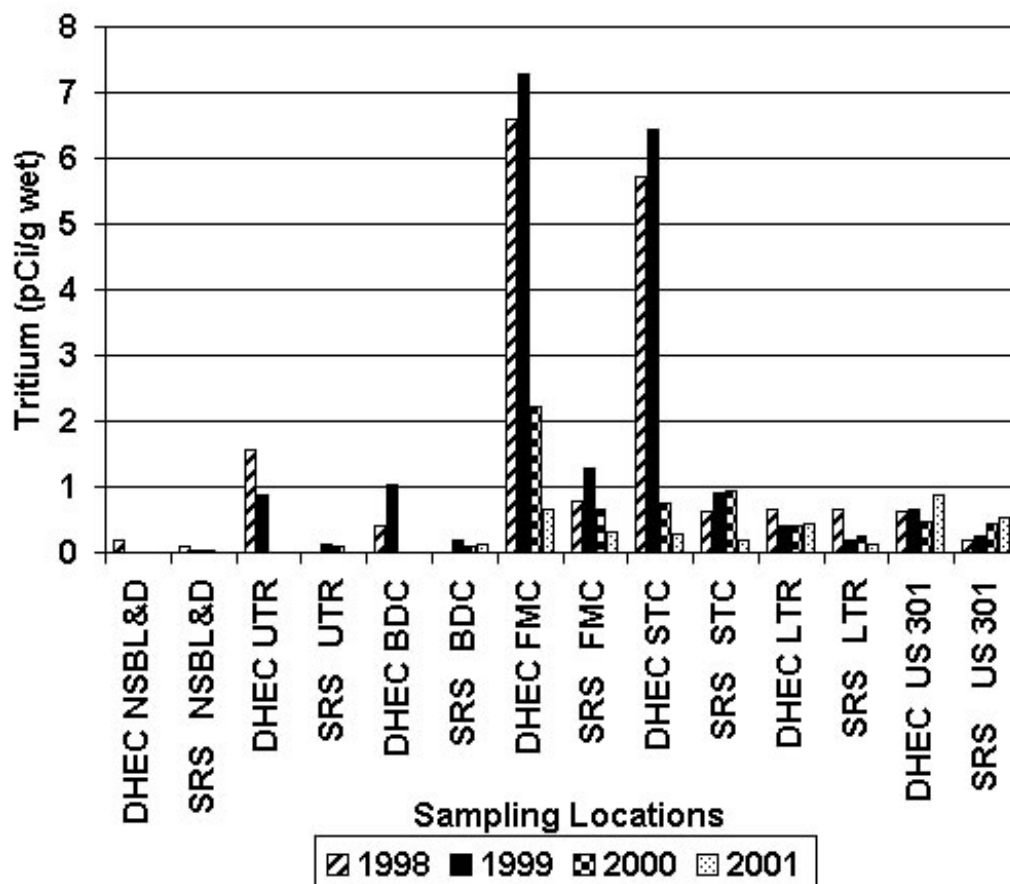


Figure 13. Cesium-137 in Edible Bass for DHEC and SRS

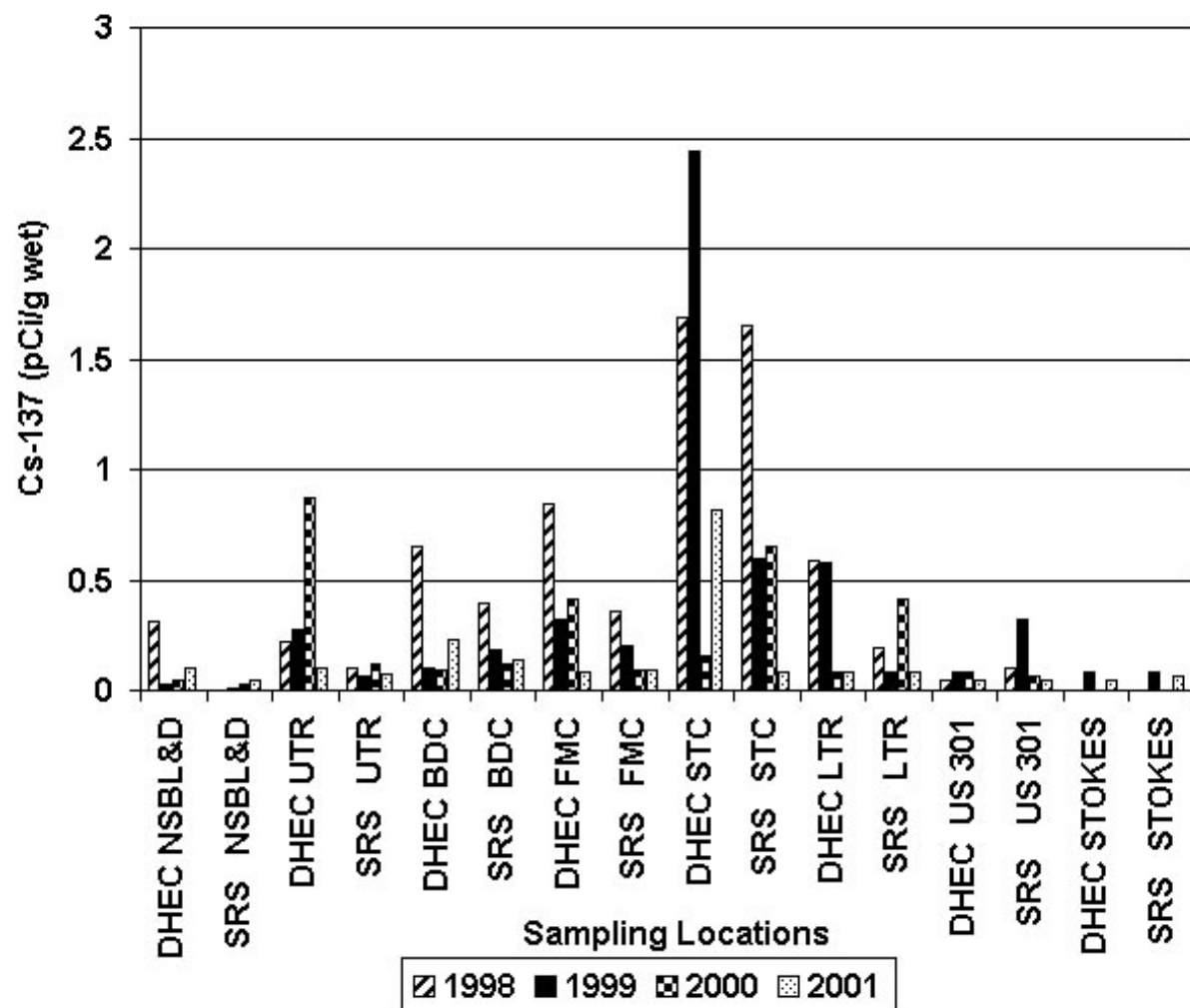


Figure 14. Cesium-137 in Non-Edible Bass for DHEC and SRS

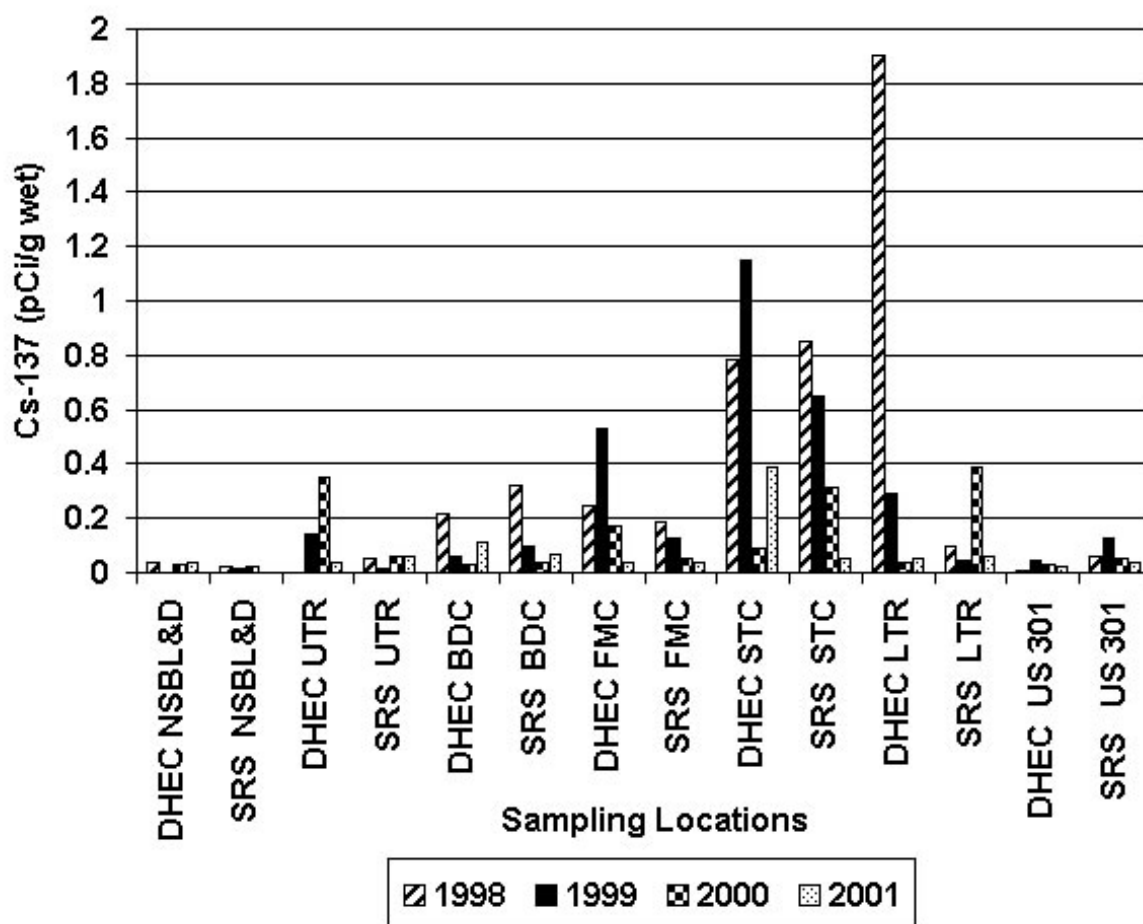


Figure 15. Cesium-137 in Edible Catfish for DHEC and SRS

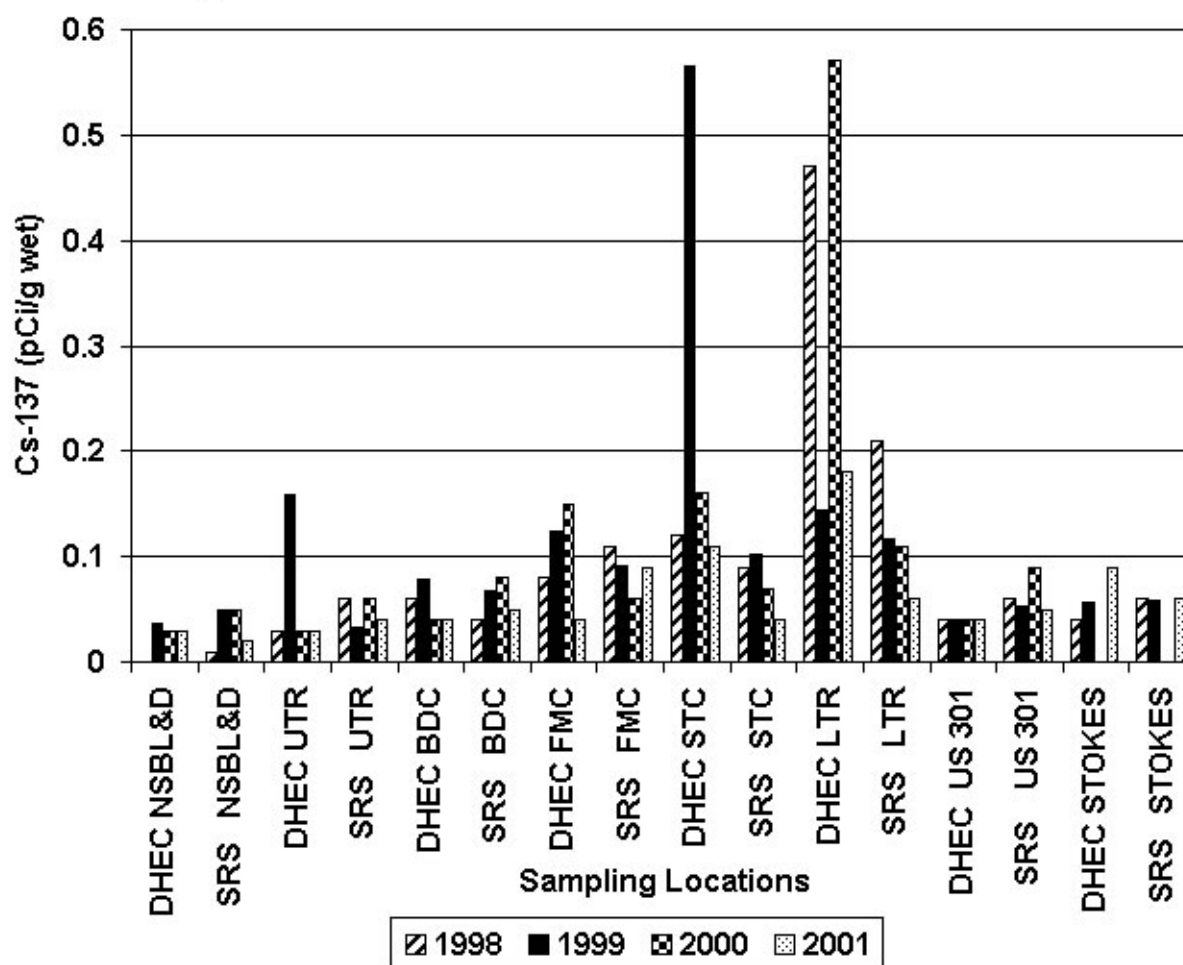
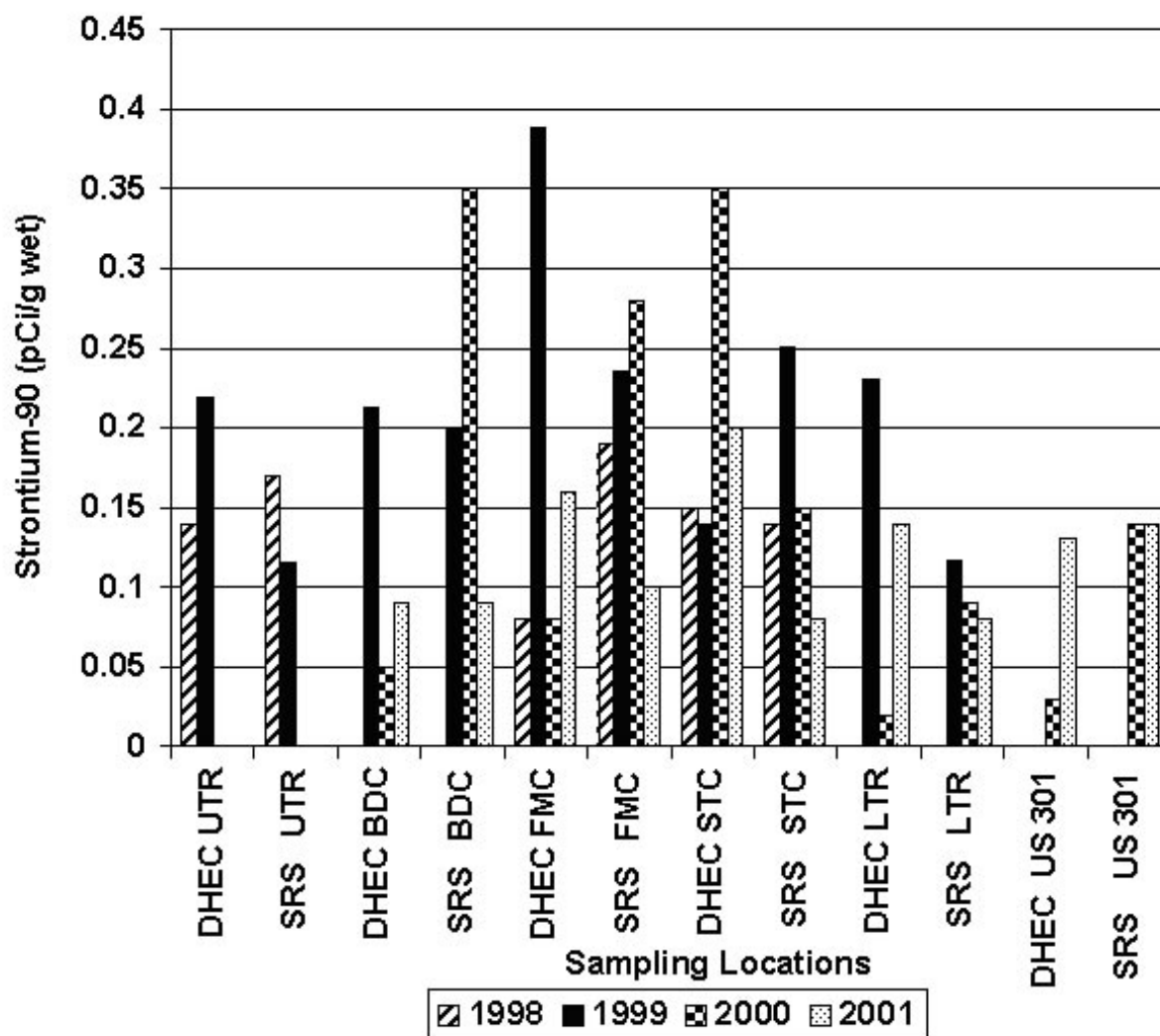


Figure 16. Strontium-90 in Non-Edible Catfish
for DHEC and SRS
(Blanks denote no comparable analyses)



Map 9. Radiological Fish Monitoring Locations



Radiological Game Animal Monitoring Adjacent to SRS

White-tailed deer and feral hogs have access to a number of contaminated areas on the Savannah River Site (SRS), and consequently are a vector for the redistribution of contaminants, including cesium-137 (Cs-137), to off-site locations. ESOP conducts the game animal study to address concerns of potentially contaminated white-tailed deer and feral hogs migrating off the SRS by analyzing game samples collected off-site. The precise ranging behavior of individual deer and hogs on the SRS is unknown. Deer and hogs have access to contaminated areas on site and it is possible that some animals migrate off-site where they can be harvested by local hunters. The radionuclide of concern is Cs-137 because of its relatively long physical half-life of 30 years and its availability to game animals and associated health risk to humans. Sampling by ESOP of deer and hogs harvested off-site can provide valuable information concerning the potential off-site exposure to Cs-137. Findings found in the ESOP's Critical Pathway Assessment of SRS and Dose study indicate that radiation exposure from ingestion of deer and hogs are greater than atmospheric and liquid releases combined

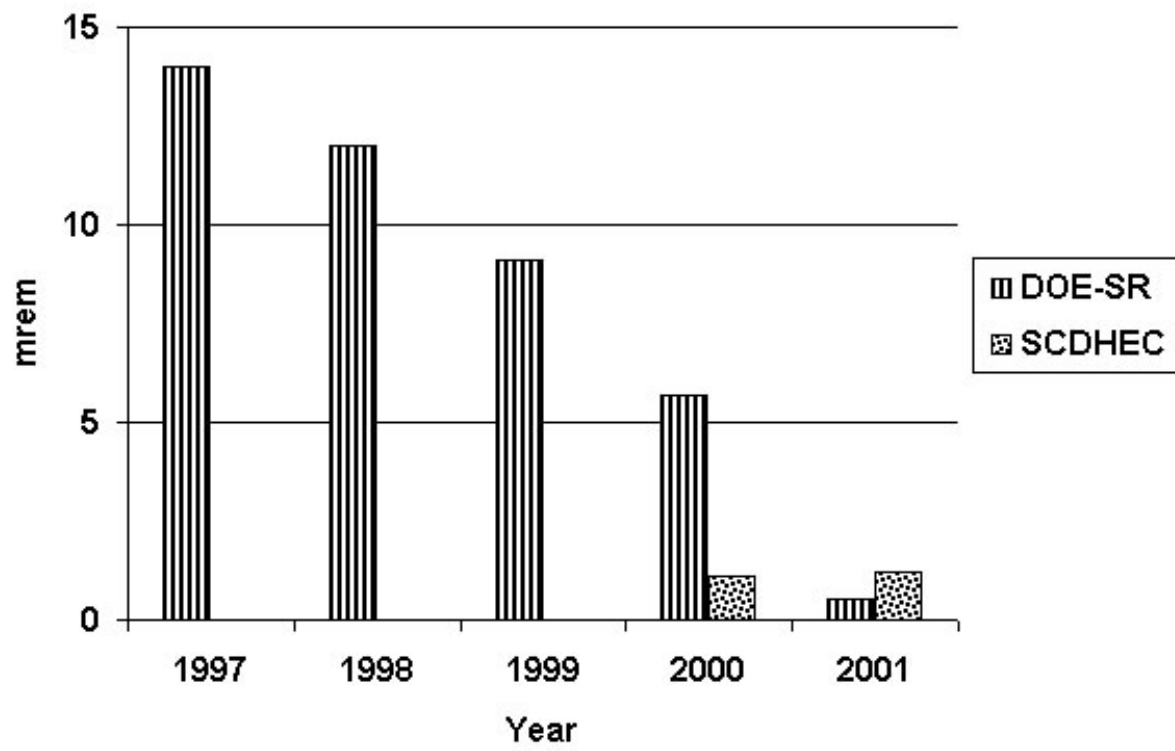
In 2002, SCDHEC analyzed muscle tissue for Cs-137 from 52 deer and four hogs from within a five-mile study area adjacent to the SRS. Six tissue samples were also collected and analyzed from a background location 50 miles northeast of the SRS. Cs-137 activities from the 52 white-tailed deer perimeter samples ranged from 0.37 to 8.86 picocuries per gram (pCi/g), with a mean of 2.18 pCi/g. Sample results from the six deer collected 50 miles northeast of the SRS ranged from 0.58 pCi/g to 1.67 pCi/g, with a mean of 0.90 pCi/g. WSRC reported an approximate field measurement range of 1.0 pCi/g to 28.0 pCi/g, with a mean of 4.00 pCi/g, from 1316 deer harvested on the SRS in 2002. SCDHEC mean values were calculated by using analytical lab data at or above the Minimum Detectable Activity (MDA). Average DOE-SR and SCDHEC Cs-137 concentrations for the past five years are indicated in Figure ????

Cs-137 activity for the four feral hogs collected by SCDHEC ranged from 0.25 to 7.19 pCi/g, with a mean of 1.99 pCi/g. WSRC reported an approximate field measurement range of 1.0 pCi/g to 16.95 pCi/g with a mean of approximately 4.07 pCi/g from 168 hogs harvested on the SRS in 2002.

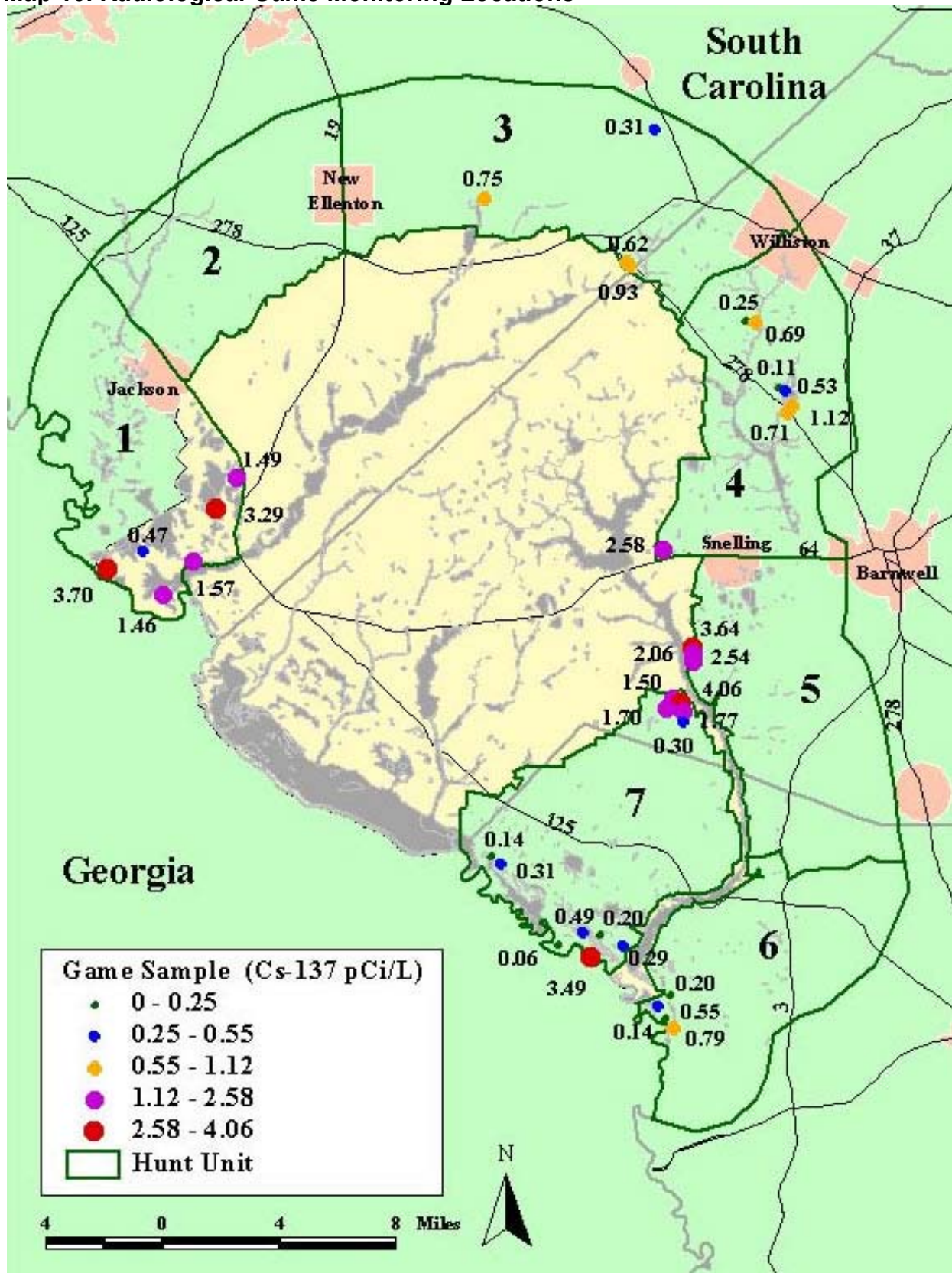
WSRC does not collect game animal samples within the SCDHEC study area, therefore no direct comparisons could be made between ESOP and DOE-SR.

During our study, slightly elevated Cs-137 (> 1 pCi/g) concentrations were noticed in all of the seven-study area hunting units. Age, sex, body weight, soil type and location of collection may affect the Cs-137 activities found in white-tailed deer and hogs. A portion of the elevated Cs-137 activity found in deer harvested in hunts units five and seven may be attributed to historic site operations. Historic site operations released known Cs-137 contamination to lower three runs creek and floodplain, which divides hunt units five and seven. Further, future research may be needed to help determine why elevated Cs-137 activities are found in other hunt units. ESOP will continue to monitor deer and hogs within a five mile study area.

Figure 17. Game Animal Average Off-site Dose



Map 10. Radiological Game Monitoring Locations



New Initiatives:

Cow and Goat Milk and Meat Consumption Pathways

An effort is underway in 2003 to increase the milk consumption pathway sampling by including goat milk, and investigate the need for cow and goat meat samples. Goats are being included since goat milk has a higher transfer factor for tritium oxide than does cow milk (Jannik, WSRC). Dairy cow milk sampling and goat milk sampling will be conducted on a quarterly basis within approximately a 50 mile radius of SRS. The milk samples will be sampled for tritium and selected beta-gamma-emitting radionuclides (I-131, Cs-137, Co-60, Sr-90).

Surface Soil Inhalation and Ingestion Pathways

Radiological monitoring will include Technetium 99 for the first time along with continuing monitoring of Strontium 89/90, Plutonium 238/239/240, and Cesium 137. Technetium-99 is an example of a low specific activity long-lived radionuclide that exists in SRS seepage basins that should be sampled around the SRS perimeter for a baseline since its long-term importance on a percentage dose/risk basis will increase (Jannik, WSRC).

Soil sampling for 2003 will be conducted in conjunction with vegetation monitoring to determine any correlation between soil deposition and plant materials or uptake, and will continue to support the background soil metals analysis effort with arsenic detection levels reduced to 1 mg/kg or less. The average concentration for arsenic in the coastal plain area is 2 ppm (Canova, 1999) and includes the SRS area which has higher levels of arsenic in some areas that may be resuspended in the atmosphere or surface water runoff through clean up and other soil disturbance activities.

Sportsman Pathway

SRS had found elevated levels of Cs-137 in mushrooms during some 1980's studies and noted that deer and some other animals exhibit a preference for mushrooms in their diet (SRP Environmental Reports for 1982 through 1985). No clear correlation was established between yearly variations of cesium in deer and yearly variations in mushroom abundance and weather conditions. However, the yearly maximum levels of cesium 137 were 70 pCi/g (dry weight) in 1985, 640 pCi/g in 1984, 540 pCi/g in 1983, and 20 pCi/g in 1982, and may be related to some other activity such as ash deposition from prescribed burns.

Fungi grow as saprophytes or parasites on decaying plant and animal products, and their nutritional requirements primarily depend on carbon, nitrogen, potassium, sulfur, phosphorus, and magnesium, and essential micronutrients such as iron, zinc, copper, manganese, calcium, molybdenum, various enzymes, vitamins, and other metabolites (Moore-Landecker, 1972). Ash from prescribed burns is an example of a growth stimulator for fungi. This could affect the levels of radionuclides consumed thru the wild game pathway and the local mushroom industry. Mushrooms at the surface soil collection sites and elsewhere will be studied as bioconcentrators of radionuclides and potential early warning indicators of radionuclide dose increases initially thru in-situ MCA analysis of radiocesium and possibly other radionuclides.

Critical Pathway Assessment of SRS '02

The Savannah River Site (SRS) is a Department of Energy (DOE) facility located in South Carolina that produced nuclear materials for the national defense during the cold war era. Throughout its operational history there have been documented instances of radiological materials that were released to the environment during production activities. A critical pathway assessment of the SRS was performed that included reviewing DOE documented instances of radiological materials released to the environment during the site's history. Added emphasis was placed on releases that occurred during the past eight years (1993-2000). From these document reviews, the primary radiological contaminants released by the SRS and the exposure pathways leading from the SRS to the surrounding public have been identified. This assessment only considered radiological contaminants even though there is non-radiological contamination on SRS. Non-radiological releases will be evaluated at a later date.

The major radiological contaminants released into the atmosphere by the SRS are tritium, iodine-129, cesium-137, and plutonium-239. Radionuclides that make up the key contaminants in liquid releases from the SRS include tritium, strontium-90, iodine-129, cesium-137, and plutonium-239.

The surrounding public is potentially exposed to radiological contamination from the SRS through inhalation, ground and sediment shine, dermal absorption, and ingestion exposure routes. The ingestion and inhalation exposure routes are the major mechanisms for exposure to radionuclides released by the SRS. Consumption of vegetation, surface water, fish, and game animals are major contributors to the ingestion exposure route. The greatest source of radiation exposure is provided through the sportsman exposure pathway. During the last eight years the dose received by the sportsman (on-site hunter, off-site hunter and off-site fisherman) has been greater than the maximally exposed individual from all atmospheric and liquid releases. These findings indicate that environmental monitoring programs should focus on the sportsman, inhalation, drinking water and vegetation exposure pathways.

Future activities consists of a technical review of the "Assessment of SRS Radiological Liquid and Airborne Contaminants and Pathways" developed by WSRC; a comparison of the WSRC critical pathway assessment to their current environmental monitoring program; an evaluation the effectiveness of the DOE-SR environmental monitoring program and use of data in determining dose to the off-site population; and recommendations regarding improvements to both the ESOP and DOE-SR environmental monitoring programs.

